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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The B.C.I.R.A. Scottish Laboratories are:—
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Forthcoming Events.

Institute of British Foundrymen.

APRIL 13.

Birmingham Branch (Junior Section):—Discussion on "Pattern-making Problems," opened by T. E. Gough.

Newcastle and District Branch (Junior Section):—Annual general meeting. General discussion on "Foundry Work."

Wales and Monmouth Branch:—Annual general meeting at Cardiff.

APRIL 19.

Middlesbrough Branch:—Annual meeting at the Cleveland Technical Institute, Middlesbrough.

Sheffield Branch:—Annual meeting. "Recent Developments in Cupola Control."

Coke Ratios.

The significance of the branded name applied to such foundry materials as pig-iron and coke has lost much of its importance in the eyes of the modern foundryman. This must be regarded as a direct result of the broadening of individual knowledge of the properties of foundry materials and the modern developments in transport facilities and the rapid dissemination of news and knowledge. This is true to a greater extent in the case of pig-irons than in the case of foundry coke. This latter material cannot yet be said to have surrendered to the activities of our scientific investigators, and names and brands still carry considerable significance in the foundry industry. It is, of course, well known that scientific investigation of coke supplies is now proceeding rapidly, and the foundry possess an articulate voice in this work through its Research organisation, Institute and Employers' organisations. That such investigation should be directed towards the improvement of the efficiency and economy in the utilisation of coke needs no elaboration.

It is not always realised that the question of fuel economy in foundry melting practice has always been one to receive attention in the earlier days of ironfounding. The student of the development of ironfounding will find the outstanding fact that all of the many proposals for fuel economy in the cupola invariably claimed prompt attention. So they do to-day. The proposals which have been made are innumerable, involving modified designs and constructional features, waste heat recovery devices and "coke ratios" have been and still are the outstanding conversational topic in foundry technical circles.

Attention has been concentrated again on the question of coke ratios with the introduction of various new developments in cupola design, claimed to effect economies. In spite of the prominence given to this question, it must be admitted that there is still a great deal of confusion as to the exact meaning and value of coke ratio. Furthermore, the difficulties which exist in the ordinary simple act of measuring coke charges into foundry cupolas—in everyday practice—leave us with a grave uncertainty as to the accuracy of many of the coke ratios enunciated. These difficulties need not exist, as it is quite within the scope of the modern works laboratory to determine and construct comparative thermal balance sheets of cupolas, and this still remains the only clearly satisfactory way of demonstrating furnace efficiency.

The difficulties in the performance of such a simple act as the measuring of the coke charges has been referred to and is by no means unreal, particularly in the case of small cupolas operating with small coke charges. Even where the coke charges are weighed the psychological tendency to give the "long pull" might easily amount to an error and loss of 10 per cent. when dealing with small coke charges. The cumulative effect of such a loss in the working costs of a small cupola may amount to a considerable item. A wagon of coke of a tare weight of ten tons in many cases of small cupolas is required to split up into as many as four hundred charges, each of which might be conceivably subject to a "long pull" and consequent loss of 10 per cent. This, of course, is a partial cause of the more economical showing of large cupola plants.

Thus cupola returns of coke ratios are not necessarily infallible, and we have to rely on the cost accountants' department presenting a coke ratio determined from the invoice value of the ingoing trucks of material for the true and correct statement of affairs.

The Technical Exhibit.

Those who saw the Foundry Exhibition at Düsseldorf some years ago brought away a very clear impression of the extent and value of that section of the exhibition devoted to the purely technical and scientific side of the industry. It had been organised, with characteristic German thoroughness, by the officers of the Foundry Owners' Association, and it had taken several years to arrange. Visitors to the more recent and still more remarkable exhibition of engineering materials at Berlin had another opportunity of seeing the value of properly-directed co-operative action, for the whole of the exhibits, as far as the names of their producers were concerned, were anonymous; yet every visitor could not fail to bring away an impression of the enormous scientific and technical resources behind German industry, an impression, of course, that the exhibition was held to create.

The last Foundry Exhibition held in London saw an effort to form a similar non-commercial and, consequently, technical exhibit, so that visitors could see something of the work being done in the British industry, from its more disinterested aspects; we all realise nowadays the potent nature of indirect and group advertising. The exhibit was organised on typically British lines—the whole thing was improvised during the last few weeks before the exhibition by a group of voluntary workers, who put in a good deal of time and work to make the exhibit go; and it did prove very attractive. Visitors were the more interested in that there was no pressure to buy, and they were enabled to see the wheels going round, so to speak.

For the exhibition in June a Technical Committee has been formed representing practically every institution concerned with foundry work, and it is very strong in its *personnel*. A Sub-Committee is in charge of the arrangements, and a comprehensive plan has been formed in

which any exhibit will find its appropriate place. The promoters are now seeking appropriate exhibits, and we desire to give publicity to this, because it is quite probable that there is a certain amount of work being done which could appropriately be shown, but of the existence of which the promoters are ignorant. Proper acknowledgment will be made, both on the exhibit and in the catalogue, but it is not desired to show material which would more appropriately form part of the make-up of the ordinary exhibition stands. Specimens or castings should be complete, with test data showing the particular properties for which they are worth featuring. Apparatus or equipment showing research work, recently finished or in progress, complete with diagrams, could be set up, and supplies of electricity, gas and water will be available. The space has generously been given by the exhibition authorities, and exhibits will be cared for and insured by them. They may cover not only grey and malleable iron but steel and non-ferrous castings, as well as raw materials like refractories, sands and fuel.

We, therefore, ask all those in a position to do so to see whether they can suggest any exhibit which will redound to the credit of the foundry interest in this country, and to communicate their ideas to us for passing on to the Committee.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

On Sheer Merit.

To the Editor of The Foundry Trade Journal.

Dear Sir,—I was very interested to learn on reading your Editorial of April 4 that I possessed the occult gift of inspiring your article in 1925, without either verbal or written word. It might be advisable, now that I know, for you to take out an insurance against a repetition of such undue influence. I should also like to assure our French friends that we on this side have no other desire than to obtain a specification that will yield most information to the inspecting engineer and foundryman on the casting he has to examine. If by drilling a small piece out of a casting, *irrespective of composition, or the thickness of the casting*, and submitting the small piece to a shear test, you can state what the tensile and transverse strength of the casting will be, you have solved the problem so far as the physical properties of the metal are concerned.

I hope in the near future, with your permission, sir, to give a number of reasons why the shear test cannot be relied on to give this information. I see from your present issue that we are to be favoured with a paper on the subject by that able engineer and foundryman, M. Le Thomas. It is only fair to him that these objections to the shear test be ventilated so he can be prepared to deal with them.

The question will also come up for consideration at the International Foundrymen's Test Committee in London in June.—Yours, etc.,

J. Shaw.

Canada Iron Foundries.

The accounts of Canada Iron Foundries for 1928 show that foundry earnings before providing for depreciation were $341,922 (against $454,820), interest on investments $122,290 (against $52,744), and balance brought forward $34,199, making $498,411 (against $512,418). To depreciation on foundry buildings and machinery has been placed $195,059 (against $243,824), debenture interest absorbed $31,980, maintenance of non-operating plants $4,689, dividend of 5 per cent. on preference shares, payable April 15, takes $193,890 (against 4 per cent., absorbing $155,112), and to general reserve fund has been transferred $35,698 (against nil), leaving $37,095 (against $34,198).

Our Visitors—Early American Bookings.

The following have already signified their intention to participate in the forthcoming International Foundry Convention to be held in London in June:—

Mr. S. T. Johnson, president of the American Foundrymen's Association (S. Obermayer Company, Chicago, Ill.), and Mrs. Johnson; Mr. Fred Erb, vice-president American Foundrymen's Association (the Erb-Joyce Foundry Company, Detroit, Mich.), and Mrs. Erb.

Mr. S. W. Utley, past-president American Foundrymen's Association (Detroit Steel Castings Company), and Mrs. Utley; Mr. L. W. Olson, past-president of the American Foundrymen's Association (Ohio Brass Company, Mansfield, Ohio), and Mrs. Olson.

Mr. C. E. Hoyt, secretary-treasurer American Foundrymen's Association (Chicago, Ill.), and Mrs. Hoyt.

Mr. H. Cole Estep, Director, American Foundrymen's Association (Penton Publishing Company, Cleveland, Ohio), and Mrs. Cole Estep.

Mr. A. E. Hageboeck, Director, American Foundrymen's Association (Frank Foundries Corporation, Moline, Ill.), and Mrs. Hageboeck.

Mr. D. M. Avey, Editor "The Foundry," Cleveland, Ohio, and Mrs. Avey.

Mr. and Mrs. George F. Snyder, Pasadena, California.

Mr. and Mrs George H. Wadsworth, Wadsworth Core Machine & Equipment Company, Akron, Ohio.

Mr. and Mrs. Verne E. Minich, American Foundry Equipment Company, New York.

Mr. and Mrs. P. W. Mulder, Almont Manufacturing Company, Almont, Mich.

Mr. and Mrs. R. E. Bryant, Jefferson Union Company, Lockport, N.Y.

Mr. C. H. Gale, Grand Rapids, Mich.

Mr. James W. Gibney, W. P. Taylor Company, Buffalo, N.Y.

Mr. E. M. Ayers, Ayers Mineral Company, Zanesville, Ohio.

Mr. J. B. Goostray, Hunt Spiller Manufacturing Company, Boston, Mass.

Mr. R. F. Harrington, Hunt Spiller Manufacturing Company, Boston, Mass.

Mr. E. L. Loges, Kramer Brothers Foundry Company, Dayton, Ohio.

Mr. Joseph F. Froggett, Penton Publishing Company, Cleveland, Ohio.

The Application of Alloy Steel to Locomotive Building.

Alloy steel has been used considerably in the construction of two large locomotives which the Canadian Pacific Railway has recently put into operation. The steel bed castings and the bumper beams were cast integrally, and the cylinders, which are separate, are also of cast steel. When the cylinders and locomotive bed castings were assembled, it was found that the use of alloy steel had effected a weight reduction of over 4,000 lbs.

Miscellaneous steel castings, such as pump brackets, piston-head centres, crosshead bodies, etc., are all of cast nickel steel, which enables a decided reduction of thickness in section to be made. Sections which were previously $\frac{7}{8}$ to 1 in. thick can now be cut down to $\frac{1}{2}$ and $\frac{5}{8}$ in. without sacrifice of strength.

Low-carbon nickel steel of a new specification has been employed for the main and side rods and crank pins, and the *Railway Age* is of the opinion that in the production of each locomotive, more alloy steel has been used than in any other locomotive heretofore. The engines each weigh 423,000 lbs. without tender, and have a maximum tractive force of 60,800 lbs.

Random Shots.

The slow but sure improvement in the heavy industries seems to be continuing, and unless it is frostbitten by the uncertainty created by the General Election, the outlook seems more promising than for some time. To crown everything, the financial returns of the companies actually show that the tide is turning. They are, according to the "Times," now making on an average not less than 1 per cent. on their capital!

* * *

The curious self-depreciatory way in which we look at things is nowhere better exemplified than in Press statements relating to employment. The constant cry is that unemployment is diminishing, whereas any other country would probably say that employment is increasing.

* * *

Looked at from one point of view, the strike at the Austin Motor Works was amusing, for a whole battery of trade-union officials stood by impotent, while the men refused to take their advice and return to work. It is not so often that union officials and works managers find themselves in such cordial agreement. The moment the management decided to consider all those refusing to return to work as discharged, the strike collapsed, and the stand made by the management earned the grateful thanks of employers throughout the country.

* * *

A missionary was engaged among a cannibal tribe. For a time he seemed to be winning their hearts, but unhappily for him he put on flesh at the same time. When his parishioners considered that he was in killing condition, they laid violent hands upon him, stripped him naked, and fastened him up to a stake in the village. Here an auction was held of the various parts of his body, one of his deacons buying a leg, his most recent convert purchasing a promising shoulder, and so on. He was to be killed the next day. And that night he made his escape. Unclad, as he was, he raced through the jungle. He was hunted by wild beasts, and his flesh was torn by great thorns. Towards morning he blundered into a native village, and was brought up with a jerk against what he instantly recognised to be the wall of a native hut. And there he crouched in the darkness, almost fearing to breathe. And presently, from within the hut, he heard these words: "Hell and fury! You damned idiot! You ought to have doubled hearts!" "Thank God!" ejaculated the wretched missionary, "Thank God! I am again among Christians."

* * *

The limericks I quoted seem to have afforded some amusement. Here is another on Einstein and one on Freud.

There was a young lady named Bright,
Who would travel much faster than light.
She started one day
In the relative way,
And came back the previous night.

The young things who frequent picture-palaces
Have no use for this psycho-analysis;
And although Dr. Freud
Is distinctly annoyed,
They cling to their old-fashioned fallacies.

* * *

A noted criminal had been photographed in six positions for the rogues' gallery in an American city. The police, having been convinced that he was the man wanted for a recent crime, sent all six prints to the various police chiefs throughout the country. The chief of another town wired to the chief of police: "Photographs received, the whole six are here. We have five of them locked up and expect to capture the other any minute. Send someone to complete the identification."

Marksman.

The Economic Manufacture of the Y-Alloy.

The Y-alloy containing 1.5 per cent. of magnesium, 2 per cent. of nickel, 4 per cent. of copper, and 92.5 per cent. of aluminium, is a very useful alloy because, in the cast state, it can be improved by heat-treatment. As the methods of producing this alloy hitherto described in literature have not invariably proved successful in practice, W. Claus and E. Kalaehne* made some experiments in this direction.

At first the authors tried to produce a hardener containing the alloying elements in the correct proportion, *i.e.*, 15 per cent. of Mg + 20 per cent. of Ni + 40 per cent. of Cu + Al the remainder. This attempt, however, failed, because it proved impossible to make an alloy containing more than 2 per cent. of Mg. Besides this, the melting loss amounted to 40 to 60 per cent. Therefore the authors determined to produce a hardener containing no Mg but a high amount of Al. The composition aimed at was 20 per cent. of Ni + 40 per cent. of Cu + 40 per cent. of Al. Nickel and copper were melted in a fire-clay crucible and the aluminium was added by the piece. After several attempts the authors succeeded in producing an alloy containing 18.5 to 19.5 per cent. of Ni + 39.06 to 39.3 per cent. of Cu, Al being the remainder. The melting-loss amounted to 21 to 26 per cent. From thermal analysis it was stated that the solidification range of this alloy was from 910 to 1,020 deg. C. With the aid of this hardener the Y-alloy was produced in the following manner:—4.43 kg. of Al were

Table I.

Composition.	Heat No. I.	II.	III.
Mg	1.35	1.6	1.8
Ni	1.74	2.4	1.67
Cu	4.14	4.16	4.00
Al	92.48	91.4	93.00
Fe	0.25	0.25	0.10
insoluble residue	0.21	0.34	—

melted in a graphite crucible and heated to 980 deg. C.; then 0.5 kg. of the hardener were dissolved in the Al and the crucible was taken from out the furnace; at 700 deg. C. 0.08 kg. of Mg were added and the melt was well stirred. At about 680 deg. C. the alloy was poured in a chill mould, a dry-sand mould, and a green-sand mould. All the samples showed a homogeneous structure.

The method of production just described has, however, two great disadvantages:—The melting loss is still very high and the molten aluminium must be heated to about 1,000 deg. C. because of the high melting-point of the hardener. The high temperature, however, causes a great gas absorption with poor mechanical properties of the alloy. Therefore the authors produced a hardener containing 10 per cent. of Ni + 20 per cent. of Cu, Al being the remainder. The solidification range of this hardener was stated to be from 580 to 710 deg. C.; the melting loss amounted to 6 to 8 per cent. In this case the mixture for producing the Y-alloy is:—78.5 per cent. of Al + 20 per cent. of the hardener + 1.5 per cent. of Mg. The method of production is the same as described above with the exception that the hardener is added to the molten aluminium at about 700 deg. C. and the Mg at 680 deg. C.

Table II.

	Hardness number, kg./mm.²	
	In the centre.	At the rim.
Dry-Sand Mould:		
48 hours after pouring	75.0	77.5
96 ,, ,,	80.0	76.0
144 ,, ,,	92.5	75.0
Green-Sand Mould:		
48 hours after pouring	81.0	80.0
96 ,, ,,	80.0	82.0
144 ,, ,,	81.0	80.0
Chill Mould:		
48 hours after pouring	92.5	100.0
96 ,, ,,	92.5	100.0
144 ,, ,,	92.5	100.0

The chemical analysis of three different heats recorded in Table I show that the deviations from the composition sought are not great. In Table II the results of some Brinell tests are recorded which were taken on samples of Heat No. I.

* Die Giesserei, 1928, No. 48, pp. 1260/3.

Education in Industry.

The programme for the Annual Conference of the Association for Education in Industry and Commerce, which takes place in London on July 2 and 3, has now been settled in outline.

The outgoing President, Lord Riddell, will instal as his successor Sir Max Bonn, K.B.E., a partner in the well-known firm of bankers, Messrs. Bonn & Company, and Chairman of the London Advisory Council for Juvenile Employment.

The Presidential Address will be delivered on July 2, and will be followed by a luncheon given by the new President at the Savoy Hotel, at which leaders in industry and commerce are expected to be present. On the second day the Conference will meet at the Polytechnic, Regent Street, when Mr. Frank Pick, Managing Director of the Underground group of companies, will read a Paper on the Training of Employees, and Mr. Harold Rostron, of Messrs. Tootal Broadhurst Lee Company, will present a Report on "Training for Higher Positions in Commerce."

The Conference delegates will pay two visits to London works. On the first day they will be the guests of the United Glass Bottle Manufacturers, Limited, of which firm Sir Max Bonn is Deputy-Chairman; and on the second afternoon, at the invitation of Lord Ashfield and his fellow Directors, they will study the training given to employees at the works of the Underground group, which is so important a factor in public safety.

Scottish Ironworkers' Hours Decision.

The arbiter's decision in connection with the hours of workers in the Scottish wrought-iron industry has been issued. The decision is that there will be instituted a 45 hours' effective working week to be worked in five shifts under a two-shift system, between 6 a.m. Monday and 6 a.m. Saturday. The firms to which the decision applies are:—The Coatbridge Tin Plate Company, Coatbridge; Etna Iron and Steel Company, Motherwell; William Martin, Sons & Company, Dundyvan Iron Works, Coatbridge; Scottish Iron and Steel Company, Limited (Coates, Rochsolloch, Waverly and Woodside works).

Central Ironmoulders.

The annual report of the Central Ironmoulders' Association for the year ended December 31, 1928, shows that the funds have decreased during the twelve months by £223 and now stand at £37,009. This is attributed to the heavy expenditure on unemployment benefit, amounting to £8,511, and in State benefit, amounting to £26,644, of which £26,560 was recovered. The membership at the end of the year was 8,581, as compared with 8,518 at the end of 1927, an increase of 63. The year is described as the worst since 1922.

Conditions of Sale.

An Australian firm with which we have been in correspondence prints on the back of its notepaper the following clauses relative to their conditions of sale. We reproduce them, as they may be suggestive to some homeland foundries which are very lax in this matter:—

Conditions of Contract.

(1) *General*: Tenders are made only on the distinct understanding that the following provisions shall apply thereto.

(2) *Quotations*: Unless otherwise stated all quotations are nett and subject to confirmation before acceptance.

(3) *Care of Patterns*: We undertake no responsibility in respect of customer's patterns in our possession and same are accepted only at the customer's risk unless special arrangements are made.

(4) *Delivery*: The period for delivery commences from date of receipt of order, patterns, drawings, or other information required to enable the work to proceed.

(5) *Delay in Delivery*: We will not accept responsibility for damages, direct or consequential, arising from delay caused by strikes, lockouts, etc., or stoppages owing to breakdown of machinery or other causes beyond our control.

(6) *Guarantee*: We undertake to replace free of charge any casting found to contain any defect due to faulty material or workmanship provided that such defect is reported to us within one month from the date of delivery and the defective casting is returned to us if we so require, but it is an express condition of this contract that except for our liability for replacement as aforesaid we shall not be liable for any expense, for loss or damage to the purchaser in any way arising out of or connected with any such defective casting or the necessity for replacing the same or anything consequential thereon.

(7) *Verbal Understandings*: Verbal understandings in respect of price, delivery, or any other conditions cannot be recognised unless confirmed in writing.

(8) *Patterns*: We will not be responsible for the correctness of patterns to drawings unless they be made by us. Patterns furnished by customer should bear distinctive colours for identification of core-prints, machined surfaces and rough casting, and should be numbered. All repairs due to fair wear and tear must be paid for by customer.

(9) *Alterations*: Customer will be charged with the cost of any work discarded, due to alterations to patterns, core boxes, etc., or stopping of work.

Paisley Technical College Principal to Retire.

The retirement in September after 30 years' service of Mr. Angus Maclean, B.Sc., Principal of the Paisley Technical College, is an event which will stir the memories of many thousands of his former students now scattered all over the world. Mr. Maclean undertook the work of founding the college in 1899, and it has steadily progressed under his management. Mr. Maclean is a native of Tarbert, Loch Fyne, and was one of Lord Kelvin's assistants in the University of Glasgow. He was editor of the handbook in connection with the visit of the British Association to Glasgow in 1901. Principal Maclean has rendered much service to the local foundries, and assisted the Paisley section of the I.B.F. In order that those in distant lands may have an opportunity of contributing, arrangements are being set on foot at once for a testimonial.

The list of exhibitors appearing in the Chicago Exhibition of the American Foundrymen's Association, which is being held this week, contains only one British firm—that of the British Aluminium Company, Limited.

Venting and Gas Pressure in Moulds.*

By R. D. Welford.

Sound castings depend to a very large extent on the elimination of gases and air from the moulds in which they are made, as such gases are liable to be trapped by the metal during the process of cooling, causing defects, such as blowholes, sponginess or porosity in, and scabs on the resulting casting. Some competent authorities are of the opinion that many defects generally attributed to the metal are due to the occlusion or absorption of gases or air in the casting, instead of to the unsuitability of the metal for the particular casting in question, and experiments have definitely proved that castings made in a mould formed from non-gas-producing materials, such as plumbago and ganister, have produced sounder castings than those made in a sand mould and cast from the same metal, thus proving that soundness increases as mould gases decrease.

The introduction of permanent moulds, made of cast iron, etc., and centrifugal casting in similar moulds, has solved the gas problem as far as those particular operations are concerned, but until the ideal material for mould-making (which must be sufficiently refractory to resist the heat, strong enough to resist the inrush and flow of the metal, plastic enough to be easily moulded to shape, and non-gas-producing) is discovered, the foundryman will have to go on providing ways and means for the escape of the gases from the moulds and cores in the vast majority of moulding operations.

Defects caused by gases are extremely numerous, and are caused in a variety of ways, such as unsuitability of the sand forming the mould, through the presence of undesirable elements; too much moisture in the sand mixture; excessive local swabbing; unequal running; hard spots; lack of natural venting properties of the sand, etc.; and, by far the most important, inefficient artificial venting or means of conducting the gases, once generated, from the mould.

Effect of Raw Materials.

Some consideration should be given to the materials which form the mould or core; sand, or rather what is termed natural moulding sand, consists of silica, clayey matter, iron oxide, lime, magnesia, various alkalis, vegetable matter, and water, in a combined and uncombined form in various proportions according to the class of sand used or readily available.

Prepared, or facing and core sands, in addition have other materials added according to the class of mould or core required, such as coal-dust, manure, sawdust, cowhair, and other artificial binders of many varieties.

Facings, such as plumbago, charcoal and mineral blackings, silica powder, etc., are also used in order to give a good skin or finish to the castings.

While each and all of these materials have desirable properties, the gas production resulting from the combustible matter depends on the proportions used and the amount of moisture present in the sand mixtures and facings.

When molten metal is poured into a mould large volumes of gases are generated and may be said to be formed in the following manner: (1) By the expansion, due to heat, of the air contained in mould itself and in the pores of the sand; (2) by the steam produced from the moisture in the mould coming into contact with the hot metal, and (3) by the action of the molten metal on the coal-dust or other facings and the organic matter or other materials either in or added to the sand.

The materials of which the mould is made are porous, the pore space in sand ranging from about 25 per cent. to over 40 per cent. Thus the sand contains a large amount of air; the mould is also full of air. Air or gas expands $\frac{1}{273}$ of its volume at 0 deg. C., for every degree C. rise in temperature, or, stated in a simpler form; air is doubled in volume by an increase of 273 deg. C., so that 1 cub. ft. of air at ordinary temperature (15 deg. C.) is increased to 2 cub. ft. at 288 deg. C. and at the usual casting temperature, 1,350 to 1,400 deg. C., about five times its original volume. The air in the pores of the sand on the face of the mould becomes greatly heated and expands. In the backing sand it is heated in a lesser degree, but the suddenness of the increase in volume at the moment of contact with the metal causes the gas to strike back to the vents or up through the molten metal. As it passes backward it is cooled by contact with the cooler sand and its volume diminishes, and finally its steam content condenses. Proof of this is afforded by the fact that the sand away from the face is damper than before the mould was cast, while the sand on the face is dry and burnt. Were it not for this rapid decrease in volume the face of the mould would be blown off.

Effect of Moisture.

The moisture in the sand on heating is converted into steam. This conversion is sudden, and the volume occupied by the generated steam (at 100 deg. C.) is about 1,700 times that of the water from which it was formed, or, stated more graphically, an inch cube of water at 4 deg. C. is converted into 1 cub. ft. of steam at 100 deg. C. Steam expands on heating in the same way as air and other gases, so that a drop of water heated to 1,400 deg. C. would become (if allowed free expansion) about 8,000 times the volume of the water from which it was formed.

If prevented from expanding by finding its way either through the sand forming the mould, or through the vents, the rise in pressure would cause parts of the mould to become detached, and this is what frequently happens, the result being known as a scab. Molten iron decomposes water (H_2O) and liberates hydrogen, the oxygen combining with iron forming magnetic oxide of iron. Hydrogen mixes with gases coming from the moulds and with air forms an explosive mixture, which accounts for the small explosion when the gases from a mould are ignited.

Coal-dust, when heated, gives off about 400 times its bulk of gas, which is subject to the same expansion by increasing heat as other gases. It will be apparent, therefore, that strong facings—those with a large proportion of coal-dust—give off more gas than weaker ones, and why it is desirable to use no more than necessary to make a casting strip satisfactorily. The absorption of heat in distilling coal-dust has a cooling effect, and the gas generated deposits a carbon film over the surface of the mould, giving a cushioning effect or preventing absolute contact of the metal with the walls of the mould and preventing the sand fusing. The vegetable matter in the sand mixture also generates quantities of gases.

When a mould is filled with molten metal a film or crust of solid metal is almost instantly formed on all the surfaces of the mould or cores and thus the occluded gases are prevented from escaping at these points, while, however, the mould is being filled the gases escape from the top surface into the mould cavity and escape by means of the joints or risers.

The following figures (found by Hailstone), showing the percentage of gas in iron at different temperatures and the percentage in sound and unsound castings, are of interest:—

Casting temperature.	C.cm. gas per gram.	Composition of gases.		
		CO_2.	CO.	H.N., etc.
°C.				
1.400	0.362	0.97	28.46	70.55
1.350	0.172	1.82	25.05	73.13
1.300	0.101	2.58	24.02	73.40

While cold melted iron gives up its gases more readily, hot melted iron tends to hold the gases in solution, and the maximum degree of soundness is associated with the maximum gas content as shown by the following figures:

Iron, sound, gas per gram, 0.402 c.cm.
" " " 0.206 "
" unsound " 0.126 "
" " " 0.056 "

so that casting with hot iron and a quick-cooling range is a great help in obtaining sound castings.

Sometimes when feeding a casting bubbles may be observed leaving through the riser, and they may be, and most probably are, these occluded gases. They have, however, very little, if any, influence or effect on the venting of moulds. Green-sand moulds generate more gas than dry sand or loam moulds, due to the greater percentage of moisture present, which in dry-sand moulds is driven off in the process of drying, leaving only the water chemically combined with the sand and other materials, hence greater care in venting is required for green-sand moulds, though the question and means of providing exits for the gases apply to both classes. Loam moulds require venting equally as much as dry-sand ones, though the result is achieved by somewhat different means.

The sand and other materials used in the preparation of moulds are often not suitable for the purpose for which they are employed, their varying chemical properties, lack of uniformity in grain, excessive or too little bond, deficient amount of porosity, and low permeability, etc., are conditions which can be prevented by previous examination and analysis, and thus the natural venting properties of the sand takes advantage of and excessive generation of gases prevented.

Grain-Size and Venting.

Uniformity of grain-size especially has a very important bearing on the venting of moulds, as the sand may contain an undue proportion of silt or very fine sand which fills up the pore spaces between the coarser grains and makes it more difficult or impossible for the gases to escape through the sand, and they take the only other way, that is, through the metal. The preparation, or lack of preparation, of the sand also has a great influence on the venting properties of the sand or loam, which is often over-milled, sometimes owing to neglect of the man in charge of that operation. Milling has the effect of pulverising the sand, especially when in a dry state, thus increasing the amount of silt.

The amount of moisture or the water content is of equally great importance, as it is evident that in addition to decreasing the permeability, the more moisture there is the more steam is likely to be generated, the magnitude of which has already been demonstrated. If more care and attention were bestowed on the selection and preparation of sands, advantage could be taken of the natural venting properties of that material by using some of the many methods of mechanical ramming, which at the same time will obviate much manual labour and increase production. In ordinary ramming, hard patches alternate with soft ones. It might be said that a good moulder can ram evenly, but even the good moulder, after he has drawn his pattern, feels carefully all over the surface of his mould and not infrequently finds soft places which he has to make good, and if that is so on the surface

* A Paper read before the West Riding Section of the Yorkshire Branch of the Institute of British Foundrymen, Mr. W. G. Thornton presiding.

it is more likely to be also the case further away from the pattern. Gases or steam striking through a soft place and coming into contact with either a hard or damp patch, through which they cannot penetrate, are very likely to force part of the mould surface into the metal by the power of expansion.

Mechanical Ramming Superior.

By mechanical ramming, however, a mould or core can be produced of a more even density, the sand being evenly packed all round and over the pattern. This is a great advantage compared to the uneven hand ramming. A mechanically-rammed mould is more naturally self-venting, and it is not often necessary to use a vent wire, the regular packing and diminishing density making it easy for the gases to escape and the necessity for artificial venting is almost entirely obviated. Sand used for mechanical ramming is normally drier than for hand ramming, thus reducing the quantity of the gases formed and facilitating the escape of that which is generated. The practice of venting varies in different districts, each district suiting their practice to the sands used. The density of the mould should be such, that beside having sufficient strength to resist the flow and pressure of the metal, it is sufficiently open to allow the gases to escape quickly.

This combination is most difficult to obtain in green-sand work, and as the mould must be rammed to suit the pressure of the fluid metal, the permeability of the sand must be assisted by venting. Venting of moulds is capable of very wide interpretation, as, besides making holes for the gases to pass through, straw ropes, ashes, wax vents, etc., are used to form passages for the gases to escape. In small moulds the use of the vent wire is the universal method, which is often much abused, and the pattern suffers from innumerable small punctures. The vent wire need not come in contact with the pattern at all, $\frac{3}{4}$ in. is quite near enough, as the pressure of the metal and gases combined is sufficient to force the gases through the intervening sand. In addition, when the wire is forced into the pattern, unless the face of the mould is well worked over the metal has free access to the small holes left, often filling them and nullifying their usefulness as vents.

Venting Bottom Parts.

When moulds are vented, a means of escape should be provided for these vents, bottom parts are often carefully vented and then the box part is rolled over on to a bed of sand and very often rubbed down in order to obtain a sound bed, thus filling up the vent holes; means of escape can be provided by venting under small boxes by means of a long wire and by forming trenches by means of an iron bar or straight-edge in the case of large ones.

When moulds are vented down the sides, the vent wire should be used from 1 to 2 in. from the pattern and at intervals of from 2 to 3 in., and the gases conducted away by means of a channel filled with ashes or a straw or hay rope laid in. This is a better method than simply making small channels from the vents to the box edge, as there is no fear of the metal getting into them. It must be remembered that no vents are preferable to vents blocked up and thus forming small pockets of expanding gas.

Moulds made in the floor may have the gases conducted away either by means of vents made with wires or rods or a bed of ashes placed under the mould, which is vented down into it. Small moulds can be satisfactorily vented by means of a wire, curved in order to get under the pattern.

It is, as a rule, more difficult to vent the bottom surface than the sides or top. The natural tendency of gas is to rise, and this is only prevented by the pressure of the metal covering the bottom. The mould often blows slightly when the metal first covers an open sand mould bottom, and as the metal increases in depth and the pressure increases this blowing ceases. A similar action takes place in closed moulds. With the sides it is rather different, as the gases generated, as the rising metal comes in contact with the sides of the mould, can escape upward in their natural way.

Cinder Beds.

Venting bottoms is best done by means of laying down a cinder or ash bed, this bed should be about 6 to 9 in. below the surface of the pattern and from 4 to 6 in. thick, and covered over with hay, straw or old newspapers in order to keep the bed clear from sand. Ample outlets, such as iron pipes should be provided, as they are preferable to ramming up a wooden plug and then withdrawing it. Pipes are more easily kept clear, especially if the bed be required for several castings.

Two general methods are in use when venting bedded-in moulds, the first to vent the surface of the mould after the pattern has been bedded down or rammed up, and the second to vent with a large $\frac{3}{8}$- or $\frac{1}{4}$-in. wire the sand bed before the facing sand is put on, these form the main vents and after the facing sand is put on and the actual surface of the mould formed, it is vented down to the main vents by small wires. This is probably the best method wherever possible. Though dry sand moulds do not require as much care in venting as the green sand variety, the same principles apply. Dry sand moulds are more permeable owing to the removal of the moisture, thus having more pore space for the escape of the gas, and at the same time less gas is generated due to the absence of such moisture. A reason for venting dry-sand moulds is often overlooked, and that is that it facilitates the drying by allowing the steam to escape more readily. Especially when drying large moulds in the floor, either by means of open fires or by means of mould driers, vent holes are very valuable aids to speedy and efficient drying.

Wax Vents.

Wax vents are very useful in awkward corners or thin sections of sand in dry-sand work, as the heat of the drying melts the wax, leaving a clear vent for the escape of gas. Ashes can also be effectively employed, especially in large cods of sand, in a similar way to which they are used in cores, care being taken that ample outlets are provided. Bricks, that is dry bricks, are of great assistance in aiding the escape of gases and also in drying the moulds. Placed in the corners of boxes they reduce the body of sand through which the gases have to pass and reduce the time required for drying. Loam moulds do not require so much venting as either green or dry sand. Loam, when dry is very porous and, therefore, less artificial venting is required. When a loam mould is swept by means of a strickle, only a thin layer, $\frac{3}{4}$ to 1 in., is struck up, and it is not compressed as sand is in ramming; it also has a higher percentage of water, which is eliminated during the drying process, leaving small spaces in the loam, hence the actual mould surface is porous enough to allow the gases free escape. Where the walls of a loam mould are not more than about 11 in. thick, no special provision is required for conducting away the gases, the spaces between the bricks which is filled with building loam of a very open texture being quite sufficient for the purpose; where there is a greater width of wall, ashes are the best means of venting, when ashes are difficult to obtain, dry sand makes an efficient substitute. Hay or straw ropes are used in places where ashes are difficult to place—such as under flanges and in confined places, whilst for very small places, wax vents can be effectively employed.

Venting Cores.

The venting of cores opens up a wide field, which, however, has been considerably simplified by the introduction of oil and other binders. The same principles apply as in the actual moulds, but greater care has to be taken in providing proper means for the escape of gas, which, as the cores are often almost completely surrounded by metal, are more rapid in their generation and greater in volume than is the case in moulds.

Igniting the escaping gases is often a subject for discussion. Some claim that it helps the venting, others that it does not. The greatest benefit to be derived from lighting the vents is to keep the shop atmosphere clearer. These gases have a vitiating effect on the foundry atmosphere. It is preferable to light the gases early, especially under hollow moulds such as pans, as this prevents any risk of an explosion which might damage the mould or in other moulds shake and dislodge the cores or bring down part of the mould. In any case this will prevent an accidental lighting or ignition of the gases by splashes or spark during the operation of casting.

Open or Closed Risers.

Risers play an important part in the actual venting of mould cavities, which raises the point whether risers should lift open or closed. A closed riser keeps the expanding gases under pressure, and this outward pressure helps to hold up—so to speak—the walls and the top of the mould, and it is probably best for green-sand moulds to be cast with closed risers as a precautionary measure; though often even closed risers are blown off through the force of the imprisoned gas. Dry-sand and loam moulds can safely be cast with open risers, as there is less gas generated, and that not so rapidly. In green-sand moulds the escaping gases tend to draw down the mould faces, especially the top. Small lugs or bosses on the top of a casting are better for a small riser or whistler as a vent for the gases to escape in order to allow the metal to fill that part of the mould. This is especially necessary in the case of light metals such as aluminium.

There are many other points which have a bearing on the venting properties of moulds, such as excessive sleeking, which closes the pores; clay-washing a broken part of the mould —thus giving an impervious coating—before mending it and neglecting to vent the broken parts; excessive application of water to thin sections of sand; use of too-damp sand for backing purposes; too-hard ramming. The question of venting is intimately interwoven with so many different conditions that it is almost impossible to treat it as a separate subject. Even the position of the mould, whether it be horizontal, vertical, or inclined, has a great influence on the prevention of gas troubles, whilst the method of slow pouring gives good results partly because it allows more time for the gases to escape before the mould is filled, so that one can truthfully say that the successful production of castings depends to a very large extent upon what might be termed minor details in moulding, of which not the least of these is venting the moulds to suit the varying conditions involved.

DISCUSSION.

The Chairman (Mr. Thornton) said Mr. Welford was a man of wide experience in foundry work, and he wished to take that opportunity, also, of saying that he owed him a good deal, as he had taught him loam moulding in his youth,

In answer to a question as to what method he considered the best covering for a closed riser, Mr. Welford said that with a heavy green-sand riser he preferred a thin layer of loam round the top of the riser surmounted by an iron weight.

Mr. G. Nield (Leeds) said he usually found, in regard to the sudden release of pressure, that the best way was to get a ball of cotton waste packed into the riser, and a little loose sand on top. The air was then released gradually instead of suddenly. All the gases should pass through the vents, not through the risers.

Mr. Welford pointed out that putting cotton waste into a riser was liable to introduce dirt into the mould. He had never yet seen a riser

with a weight on top lifted off by the gas. Actually, the air was not supposed to come through the riser. The reason for covering was to force the air through the sand.

Scabbed Tops and Risers.

A Member said Mr. Welford stated that the rush of gases caused the roof of the mould to come away. The drawing down was forcing down. If the riser were kept covered pressure was maintained in the mould and the mould was held up against the pressure developed by the moisture already in the sand.

Mr. Welford: In the open riser in a green-sand mould, the air rushes out very rapidly and has a tearing effect on the surface of the mould. If vents were left without lighting, the result would generally be the same, except that the atmosphere tended to become polluted, and there was always the risk of a blow. He generally lit the vents before the mould was full, because in some cases there may be a danger of explosion through waiting.

Mr. E. Farrar cited a personal experience. A long pillar, up to 15 or 16 ft. long and about 12 in. diameter, was cast first in a small shop in which there was some overcrowding. In the mould next to it was a flat plate. When the moulders started to pour this flat plate—about a 4-ft. top part—the top part and its weights were lifted up by the gas escaping from the pillar. Both jobs were bedded in the floor. He thus thought the gas would pass through a mould without lighting.

Wetting Sand to Prevent Blows.

Mr. H. Summersgill (Bradford) said he remembered an old moulder who used a quantity of water, particularly for "Gypsy" pots, maintaining that if it was not sufficiently wet the metal, when poured in, simply dried it further and ate the sand away, and he (Mr. Summersgill) never saw that man have a waster under those conditions. The fact, of course, seemed to be that in some cases wet sand was desirable, and in other cases dry sand.

The Chairman agreed that one wetted the mould to strengthen the sand so that it would not "blow." When the metal came to the portion that was wet it had already dried that sand, therefore it did not blow. If that were being done with a flat plate he (the President) thought Mr. Farrar was correct. By the time the metal had fallen on the sand which was wet, that sand had become dry, and therefore the metal was not lying on wet sand.

Mr. A. S. Worcester (Huddersfield) said it must always be borne in mind that there were scabs from causes other than moisture. Probably the greater part of the scabs to-day—they were nearly always by the runner—were due to the sand being not sufficiently refractory. It was rather misleading to give for moulding-sands a table of times of milling and percentages of moisture unless one could be given some idea as to what the grain of the sand would stand, because there was a breaking-down point. In regard to mechanical ramming, it was surprising how well a regularly-rammed mould would stand up, which he assumed was due to its venting properties. In regard to wax vents, Mr. Worcester thought, to take care of the amount of its volatile matter, it demanded extra space in the vents for getting it away. The best way was to maintain the temperature of the stove at such a temperature that one would be sure that the greater part of the volatile matter was evolved as gas.

Mr. Welford wished to make it clear that he did not suggest that all scabs were due to moisture. A very large number of scabs was due to striking the pattern of the rammer. The scabs in front of the runner were mostly due to the metal running over that place, with erosion of the mould if it was too dry. Tapers were fairly good substitutes for wax vents, but in the latter there was only one single string to pull out, so it gave a clearer vent than with the many strings of a taper. He would warn members against using a wax vent where it was dried before blacking because it formed a waxy portion which would not take the blacking.

Efficient Venting Thickness.

The President said he wondered whether Mr. Welford had any data as to how far a vent would operate; it varied, of course, according to the class of sand and its dampness. Personally, he thought 6 in. Undoubtedly one of the main factors in venting a mould was the condition of the sand, whilst the size of the grain had much to do with it. For the last three years he had had no pricker in his shop, and it was a shop where they rammed hard. There was neither a riser nor a pricker near a mould, yet he had not seen a blown casting during this period. They used very dry sand and they kept the grain size within a reasonable limit by milling. All the ramming was effected by the machine. The pressure on a 20-in. dia. box was 14 tons with sand 6 in. thick. Under-ramming was uncertain. The temper of the sand and the mixing were of vital importance. To-day in most foundries every sand was tested before going into the machine, and there was no doubt it was well worth while.

Standard Sand and Venting for Adaptability.

Mr. Turner said those who could choose their sand were fortunate. Most men had to use the same sand for one job as for another, despite the fact that it was not equally suitable for all.

The President said that in such case one had to make it as near right as possible for each job by venting. In regard to the tables Mr. Welford had cited, the differences were due to the grains being powdered.

Mr. Welford said he quite agreed with Mr. Thornton as to the 6 in. striking through in a top part. He had seen it strike through as far as 8 in. of sand in the top part. It would not go through so far in a bottom part, because it had to strike down.

Mr. Harrison thought anything with a thin rim round it should do without risers and should have plenty of whistlers, which acted as a riser. One learned a great deal by one's own personal experience, and the methods employed in one shop would not ncessarily work exactly in the same way in another shop.

Mr. Welford said in regard to gas travelling from one mould to another through coke beds, to his mind that was a great blot on any foundry management. Every coke bed should be taken up when finished with, so that one was always sure there was a clear floor. A coke bed had to be taken up sometimes, and it was mistaken policy to leave it in for the sake of saving an hour or so in labour and running the risk of ruining an expensive casting.

Vote of Thanks.

Mr. T. H. Hions (Bradford) moved a vote of thanks to Mr. Welford, and Mr. J. J. Watson (Huddersfield), seconding, said he was quite sure that the young men present that evening, if they cared to continue their studies in the science of moulding, would reap very great benefit.

Mr. Welford, responding, said he might mention, especially for the information of the young men present, that that evening's paper had been somewhat in the nature of a *résumé* of a series of lectures he gave at the foundry classes at the Leeds Technical College.

French Foundrymen Honoured.

On April 13 there will be held at the Hotel Lutelia, Paris, a banquet to celebrate the promotion of M. H. Magdelena, the well-known French light alloy founder, to the position of Officier of the Legion d'Honneur, together with Messrs. L. Brasseur, of Luxembourg, Ch. Koehler Bernard Huet and F. Thivot, all of whom are prominent in French foundry circles and who have been decorated with the Order of Chevalier of the Legion d' Honneur.

The Iron and Steel Institute.

PROGRAMME OF ANNUAL MEETING, 1929.

Diamond Jubilee.

Mr. G. C. Lloyd (Secretary) has issued the programme of the Annual Meeting of the Institute, to be held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 2 and 3, 1929.

THURSDAY, MAY 2.

The General Meeting will open at 10 a.m., when the Annual Report and Statement of Accounts for 1928 will be presented. The newly elected President (Professor Henry Louis) will then be inducted into the Chair, and, after the presentation of the Bessemer gold medal to the Hon. Sir Charles Parsons, will deliver his Presidential Address. Papers Nos. 2, 8 and 14 (see appended list) will then be presented and discussed.

At 2.30 p.m. the Afternoon Session will commence, when Papers Nos. 4, 15 and 5 will be discussed.

In the evening, at 7 for 7.30 p.m., the Annual Dinner of the Institute will be held in the Grand Hall, Connaught Rooms, Great Queen Street, London, W.C.

FRIDAY, MAY 3.

At 10 a.m. the General Meeting will be resumed. An announcement of the award of the Andrew Carnegie Research Scholarships for 1929-30 to Dr. Arthur Bramley will follow, and Papers Nos. 10, 1, 12, 7 and 9 will be discussed. In the Afternoon Session, at 2.30 p.m., Papers Nos. 3, 11, 6 and 13 will be discussed.

Papers to be Read at the Meeting.

(1) Third Report on "Heterogeneity of Steel Ingots," by a Committee of the Institute.
(2) First Report on "Blast Furnace Plant and Practice," by a Committee of the Institute.
(3) "Brittleness in Mild Steel," by G. R. Bolsover.
(4) "The Erosion of Guns," by R. H. Greaves, H. H. Abram and S. H. Rees.
(5) "The Mechanical and Metallurgical Properties of Spring Steels as Revealed by Laboratory Tests," by G. A. Hankins and Miss G. W. Ford.
(6) "The Differential Method for Measuring the Thickness of Hard Cases without Sectioning them," by E. G. Herbert and P. Whitaker.
(7) "The Transformation of Austenite into Martensite in a 0.8 per cent. Carbon Steel," by Dartrey Lewis.
(8) "Twenty Months' Results of Dry Blast Operation," by E. H. Lewis.
(9) "Constitutional Diagrams for Cast Iron and Quenched Steels," by A. L. Norbury.
(10) "A New Method for the Production of Sound Steel," by the Hon. Sir Charles Parsons and H. M. Duncan.
(11) "The Oxidation of Iron and Steel at High Temperatures," by L. B. Pfeil.
(12) "The Microstructure of Rapidly Cooled Steel," by J. M. Robertson.
(13) "A Method for the Estimation of Hydrogen in Steel," by T. E. Rooney and G. Barr.
(14) "The A.I.B. Sinter Plant at Messrs. Guest, Keen and Nettlefolds, Limited, Cardiff Works," by W. E. Simons.
(15) "The Influence of Pickling Operations on the Properties of Steel," by H. Sutton.

Previous to the death of Mr. Jesse S. Jones, which occurred on January 22, the Board of Awards of the American Foundrymen's Association had decided to award to him the Joseph S. Seaman gold medal for distinguished accomplishments in the non-ferrous foundry field. The award, however, was made posthumously at the annual banquet, held on April 10, in connection with the Annual Convention of the Association.

History of Ironfounding in the Midlands.*

By D. H. Wood.

1.—HISTORICAL SURVEY.

The history of the Midlands, presenting many features of unique interest, with an intimate bearing upon national economics and industrial development, has been written in terms of coal and iron. It was not here, however, that the earliest coal hewers and ironworkers in Britain were to be seen.

When the Romans, profound believers in the law that might is right, wrested the country from its native races, they found the metal already known to the primitive islanders whom they encountered on the coasts. Probably the knowledge was first introduced by nomadic wanderers from Europe, who had themselves acquired it from the east where iron had been used, mainly for the purposes of war, since the earliest biblical times.

But the Roman colonists were the first to undertake iron production in England on a scale worthy of serious notice. Wherever they settled they lost no time in utilising the natural riches which they found readily available. Their enterprise was as remarkable as their industry was prodigious. They left striking proofs of their activity in enormous heaps of cinders and offal, and as late as 1677 that extraordinary Worcestershire genius—Andrew Yarranton—estimated that the Roman cinder mounds in the Forest of Dean and at Worcester alone were sufficient to "*supply the iron works some hundreds of years,*" and he added that "*these cinders are they which make the prime and best iron, and with much less charcoal than doth the ironstone.*"

Trade followed the flag of the Romans along the great highways into the Midlands, and the iron forgers who set up smelting fires at the crossings of valleys, or on the tops of hills, on or near Icknield Street and Watling Street, where they penetrated deepest into the Staffordshire, Warwickshire, Worcestershire and Shropshire forests, unconsciously provided pointers for the ultimate destiny of the area whose industrial expansion, attested by a chain of great and prosperous towns, has had few parallels.

A Lost Opportunity.

The transition which produced the "Black Country," challenging the supremacy of the Northumberland mining area, which, previous to the eighteenth century, was known as "The Black Indies," was slow in developing. One of the facts which most strongly impresses itself upon the student of iron-trade history is the utter failure of the people in the fourteenth and fifteenth centuries to grasp the potentialities at their command. The lessons of the Romans seem to have been entirely lost upon them, and, although iron was so scarce that Parliament prohibited its exportation under heavy penalties, they made no effort to turn the existing wealth of English iron-ore deposits to account, but obtained their supplies of iron and steel principally from Spain and Germany.

The Sussex Iron Industry.

For nearly two centuries the manufacture of iron in this country was at a standstill. It was actually in Sussex that the first symptoms of revival appeared. Camden, writing in 1607, quaintly tells us that Sussex is "*full of mines everywhere for the casting of which there are furnaces up and down the country and abundance of wood is yearly spent. Many streams of water are drawn into one channel and a great deal of meadow ground is turned into pools for the driving of mills which, beating with hammers upon the iron, fill the neighbourhood day and night with their noise.*"

Many of the noble families, such as the Nevilles, the Percys, the Howards, and the Ashburnhams owned ironworks in Sussex. The Fullers won their fortune from, and owed their social rise to, the same source, and recognition of their indebtedness is implied in their family coat of arms, which fittingly shows a pair of tongs with the motto "*Carboné et Forcipibus.*"

According to one well-known authority, the total number of blast furnaces in England about 1720 was sixty, which produced an annual output of some 17,000 tons of pig-iron between them, or a total considerably below the capacity of a single big modern blast furnace. As an example, the output of a modern furnace, such as the Dowlais plant, produces approximately 3,300 tons weekly.

It may be worth chronicling as a point of historic interest that one of the last extensive contracts executed in Sussex was the casting of the iron railings for St. Paul's Cathedral. The contract was considered too large for one ironmaster to undertake, and it was consequently divided amongst several contractors. The knell of the iron trade in Sussex was rung with the destruction of the adjacent forests, the consumption of wood being tremendous. It required four loads of timber converted into charcoal fuel to make a ton of pig-iron, while for every ton of bar iron three additional loads were needed. Wood was the only fuel used either for manufacturing or domestic purposes. Coal had been more or less known in England from at least as early as 832. It was first brought from deposits on or near the coast, and so became known as "sea coal." But it had not at this time entered into serious competition with wood as a fuel, and the disappearance of the forest growths through the insatiable demands of the "*voracious iron mills*" excited the gravest apprehensions lest there should not only be insufficient timber left for naval construction, but that, as a result of the absence of fuel, "*the fishermen would not be able to dry their clothes or warm their bodies when they came in from the sea.*" Acts of Parliament were accordingly passed for the protection of the forests. The establishment of ironworks within a radius of twenty-two miles of London was prohibited, and iron manufacture was distributed over other parts of the country, including South Wales and the Midlands. The tightening of the restrictions against wood consumption plunged the industry once more into depression, which was accentuated by the destruction during the Civil Wars of all the works belonging to Royalists, but out of chaos came the industrial revolution, one of the distinguishing features of which was the triumph of the Midland iron-foundry trades.

Birmingham's Original Industries.

Birmingham cutlers, we are told, supplied Cromwell's armies with pikes and swords, but the speciality of the town even at this early period was ironmongery, including every kind of article, some of daily use, and others which varied with the fashion. They ranged from nails and locksmiths' necessities to metal buttons and shoe-buckles, and included the whole of the Birmingham toy industry. The inhabitants of the town were said to be as industrious as they were skilful, and "the sound of hammering was to be heard at three o'clock in the morning." The demolition of the Welsh ironworks, followed later by those in the Forest of Dean, and the ultimate blowing out of the last of the Sussex iron furnaces, left the field clear for Midlands enterprise, and very soon the "*villages*" of Wolverhampton, Dudley, Wednesbury, etc., expanded into busy and thriving towns. As a rule, mine and blast furnace at first constituted parts of one undertaking. The ore was smelted on the spot and the amount extracted was originally limited by the demands of the ironworks in the immediate neighbourhood.

There was amongst the early ironfounders, as amongst householders, a strange unreasoning prejudice against the use of coal. The old manufacturers, indeed, held it to be impossible to reduce the ore by any other means than charcoal of wood, and their resistance to the innovations and improvements in methods of iron production which so speedily raised England to the status of the chief metal-working country in the world and, incidentally, established the reputation of the Midland ironfounders on a basis which has never since been seriously shaken, stands as one of the most amazing historic examples of short-sighted ignorance on record.

Then, as now, the very foundations of society, "*the tools and implements of peace,*" as Smiles expresses it, "*as well as the weapons of war,*" depended upon an abundant supply of iron, and the policy which contributed to its curtailment was, in effect, a dangerous public menace.

How foolish it had really been was emphasised by nothing so much as the gigantic leap forward which was taken when the industry was liberated from the shackles of narrowness, and welcomed the inventor as an auxiliary instead of fearing him as an enemy.

A miracle of transformation was effected, and all classes shared in an unprecedented spell of prosperity. Vivid pictures have been presented by Dickens, Disraeli, and other eminent writers of the extraordinary spectacle of feverish industrial activity which the Midlands presented in their response to inventive genius. From thousands of chimney stacks dense clouds of black smoke poured unceasingly, to hang over the whole district like a pall. From mines, mills and forges came a no less insistent volume of sound, while at night the glare of blast furnaces lit up the whole countryside, producing effects which left an ineradicable effect upon the minds of strangers.

The Development of Smelting.

Necessity compelled the ironmasters to turn to substitutes for wood-ash or charcoal in the smelting of iron, and at the outset they groped very hesitatingly with the problem in those trying and difficult times. The most perplexing trouble presenting itself in their tentative experiments with coal as a fuel arose out of the action of iron ore in contact with the sulphurous compounds liberated from coal by the process of combustion. It was found that the iron first yielded was impure and brittle, and it was quite impossible to hammer it.

Progress was really held up until 1612, when a certain Simon Sturtevant, who, if not a German, was certainly of German origin, secured letters patent conferring upon him the exclusive right to "*neale, melt and worke all kinds of metal oares, irons and steeles with sea-coale, pit-coale, earth coale and brush fewell.*"

Sturtevant, whose idea seems to have been to reduce the coal by an imperfect combustion to the condition of coke, and so rid it of "*those malignant proprieties* (sic) *which are averse to the nature of metallique substances,*" set up extravagant claims for his discovery, contending that it "*will prove to be the best and most profitable business and invention that ever was known or invented in England these many years.*" But nothing came of it. Before the year was out, his patent was declared to have lapsed on the ground that he had failed to use it. His rights were transferred to John Rovenzon, a *protégé* of the then Prince of Wales. Like Sturtevant, he, too, promised a good deal more than he found it possible to perform, and it was left to Dud Dudley, the natural son of Edward, Lord Dudley, of Dudley Castle, to prepare the way for the palmy days of the iron trade with his discovery of the process of "melting iron ore, making bar-iron, etc., with coal

* A Paper presented to Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, Mr. Starr presiding. The Author is Managing Director of the Constructional Engineering Company, Limited.

in furnaces with bellows." His patent was taken out by his father—Lord Dudley—in 1620. Dud Dudley, a student at Baliol College, Oxford, was gifted beyond the ordinary with capacity for scientific investigation, and practical experience, gained at an iron furnace and two forges belonging to his father in the chase of Pensnet, Worcestershire, set his mind working along new lines, presenting a wide field for exploration.

Dudley's Experiments.

As the result of his experiments, Dudley evolved a method of adapting coal as a fuel by subjecting it to a process similar to that of charcoal burning, and, by way of complement to a discovery which more than fulfilled expectations, he devised an improvement of the blast which enabled him to maintain the active combustion of the fuel and so increase its effectiveness. He was particularly fortunate in tapping a splendid seam of coal running from ten to sixteen yards thick, and he produced a "good merchantable iron," both at Pensnet and also at Cradley where he erected a new furnace. But both the ironsmelters and ironmasters of the district, embittered by the fact that he was able to make good iron and sell it more cheaply than they could, regarded this new process as "a dangerous invention," and appeals were actually made to King James to stop him from working. These efforts were unsuccessful, so law suits were fastened upon him, He was ousted from his works at Cradley, but set up furnaces at Himley and Hasco Bridge, near Sedgeley, which latter were wrecked by rioters at the instigation of the charcoal ironmasters. He himself was attacked by mobs, and, finally, after a career full of vicissitudes, during which he served in the Royal Armies, he settled for a time at Green's Lodge in Staffordshire, and finally retired to St. Helen's, Worcestershire, where he died in 1684 at the age of 85.

Yarrington, Blewstone and Darby.

Other great figures crowd upon the vision in that expansive period; men who contributed in no small degree to the improvement of the processes of production and to the general advancement in material prosperity of the iron-foundry and kindred trades in the Midlands.

While Dud Dudley was busy soldiering, Andrew Yarranton, the Worcestershire farmer's son from Larford in the parish of Astley, entered upon the manufacture of iron at Ashley, near Bewdley. He it was who wrested from Saxony, as the result of a personal visit and observations, the secret of tin-plate manufacture, and introduced the trade to this country. He was also responsible for setting on foot various schemes of public utility, and he gave the first impetus to plans of inland navigation, which found their fulfilment in the construction of the network of canals ultimately established to serve the needs of Midland industries. Yarranton profited by the Roman cinders left near the walls of Worcester and transported thousands of tons, it is said, along the Severn to his iron furnaces to be melted down into iron with a mixture of the Forest of Dean ironstone.

There are records of experiments between 1677 and 1686 by a German named Dr. Blewstone, who built his furnace at Wednesbury, with "*a new and effectual way of melting down, forging, and extracting and reducing of iron and all metals and minerals with pit coal and sea coal, as well and effectually as ever hath yet been done by charcoal and with much less charge.*" The inventor's idea was to permit only the flame of the coal to reach the ore, but the notion was more novel than practical, and he only succeeded in turning out iron inferior to that made with charcoal.

It is to Abraham Darby, the first of a succession of ironmasters bearing the same name, that the credit of first adopting the smelting of iron by means of coke and coal on a large scale as the regular method of manufacture belongs. Darby, the son of a farmer at Wren's Nest, near Dudley, had served an apprenticeship with a Birmingham maker of malt kilns. But the iron trade claimed him and early in his career, emulating Yarranton's example, he visited Holland to learn the secret of making cast-iron pots. His adventure was crowned with success, and on his return to England, he adopted the most rigorous precautions to prevent the piracy of his methods by other makers. He even went to the length of stopping the keyhole of his workshop door while the casting was in progress. He had made arrangements for manufacture on a large scale at Bristol, but a disagreement with his partners compelled a change of his plans, and in 1709 he settled at Coalbrookdale, where he won world-wide fame for his castings not only of pots, kettles and other "hollow-ware," direct from the smelting furnace, but for grates, smoothing irons, door frames, baking plates, cart brushes, iron pestles and mortars and other products. In 1764 another works was erected at Horshay, a few miles away.

The Coalbrookdale Works.

It was at the Coalbrookdale works that the famous Cranege process of iron manufacture, introducing the reverberatory furnace, was patented, and the first cast-iron bridge ever erected was cast at the same foundry in 1777-8. This bridge is well known to most founders as Iron-bridge, near Coalbrookdale works and, of course, is still in existence. It is interesting to note that quite recently attention has been drawn to the fact that there are *steel* and *wrought-iron* bridges which have been in existence for 50 or 60 years and are still in good condition, whereas this cast-iron bridge has been in use for over 150 years. The extension of the Coalbrookdale works and the developments which took place there were largely due to Richard Reynolds, who took charge of the works on the death of Darby—his father-in-law.

> "That the wood of old England would fail did appear,
> And tough iron was scarce, because charcoal was dear,
> By puddling and stamping he prevented that evil,
> So the Swedes and the Russians may go to the devil."
>
> *Song of John Wilkinson's workmen.*

Puddling and the Cupola.

The ancient ironmasters obtained iron and steel by the crudest and simplest possible methods. The iron ores were reduced in conical furnaces called air-bloomeries erected in exposed places, in order to obtain the greatest blast of wind. Ore and charcoal were mixed together and the blast applied to obtain the necessary temperature.

John Wilkinson, generally known as "the father of iron trade," came to the Midlands in 1748. At Bilston he built the first blast furnace. Wilkinson experimented with this furnace until he succeeded in substituting mineral coal for wood charcoal. Since he was also undoubtedly the inventor of the cupola as it is known to-day, a reference in some detail to him will be of interest. Born in 1728, near Ulverston, he was the son of the patentee of the "laundress's box iron." During the fifty odd years he lived in the Midlands his activities were extended over a wide field. He held a partnership with his brother in a foundry at Bersham, near Wrexham, where he constructed an improved plant for boring cylinders, an invention which proved of the greatest possible value to James Watt in the building of his Soho engines; he set up a forge on a large scale at Brosley, near Bridgnorth, for the manufacture of wrought iron, and here built the first iron barges ("*which swims remarkably light*"); he cast the first large working steam engines in France for the Paris waterworks, took out a patent in 1790 for making lead pipes, manufactured ordnance extensively, and came within an ace of anticipating James Neilson in the invention of the famous "hot blast."

Wilkinson's Enterprise.

As a matter of fact, it is claimed that Wilkinson conducted experiments on similar lines to those of Neilson, at Bradley, between 1795 and 1799, and only failed through lack of an iron instead of a leather joint. Wilkinson was of hot and violent temper; he was ceaselessly at loggerheads with his brother, actually started a project in opposition to the Bersham Works, and in the end dragged Boulton and Watt into the dispute, compelling them to withdraw from him the right they had conceded for the manufacture of the all-important nozzles for their engines, and to build a foundry of their own on the banks of the canal at Smethwick. Wilkinson never forgot and never forgave. "*Peace,*" he once wrote, "*is a most desirable thing, and the more so to one of my constitution, which cannot be angry by halves. Resentment with me becomes a matter of business and stimulated action beyond any profit.*" One of his ideas was the construction of a cast-iron chapel with a cast-iron pulpit at Bilston. He actually designed and cast his own coffin, and when he died in 1808 a massive cast-iron tombstone, which he also designed, was erected over his grave. He was three times buried, twice being disinterred, and he found a final resting-place at Lindale, on the slopes of a hillside, amidst scenes of his boyhood days.

In his youth friends had prophesied that "*John sum tyme wod bee a gurt man.*" A great man he truly was, in spite of his elemental passions. He left an indelible impression upon the Midland iron-foundry trades, and enriched them by a great legacy of improvements, and Midlanders at least cannot forget that he was indirectly responsible for the establishment in Boulton & Watts' Smethwick foundry of a prolific nursery of men of invention and industry. Incidentally, it may be observed in passing that his sister married Dr. Priestley, the discoverer of oxygen, and the victim of the notorious Priestley riots in Birmingham.

It was from John Wilkinson that the manufacture of wrought iron derived its greatest stimulus, and as the iron trade gathered vigour improvements in manufacturing methods followed in rapid succession. In 1762 a patent was taken out by Dr. Roebuck for melting the cast, or pig-iron, in a hearth heated with pit coal by the blast of bellows. The iron was then worked until it was reduced to nature or metallised, after which it was exposed to the action of a hollow pit-coal fire urged by a blast until it was reduced to a loop drawn out into bar-iron under a common forge hammer.

Cranege, Onions and Cort's Inventions.

In 1766, four years before the introduction of Watt's steam engine, the brothers Cranege, one of whom was associated with the Bridgnorth Forge and the other with Coalbrookdale, invented the reverberatory or air furnace, so called because the flame or current of heated gases from the fuel was caused to be reverberated or reflected down upon the substance under operation before passing into the chimney.

Then Peter Onions produced his puddling furnace, the fire of which was urged by blast. He propounded new ideas. Having charged his furnace, bound with ironwork and well annealed, with pig- or cast-iron from the smelting furnace, it was closed up and the doors were luted with sand. The fire, which was urged by a blast admitted underneath, was to be kept until the metal became less fluid and "*thickened into a kind of froth which the workman, by opening the door, must turn and stir with a bar or other instrument, and then close the aperture again, applying the blast and fire until there was a ferment in the metal.*" The inventor declared

that "*as the workman stirs the metal the Scoriæ will separate, and the particles of iron will adhere, which particles the workman must collect or gather into a mass or lump.*" This mass or lump was then to be raised to a white heat and forged into malleable iron at the forge hammer. The next stage of iron development was reached with the discoveries of Henry Cort, who, like the Craneges, employed the reverberatory or air furnace without blast, and, like Onions, worked the fused metal with iron bars until it was brought into "balls," when it was removed and forged into malleable iron, but he carried the processes farther and increased their efficiency. The changes he introduced in puddling and rolling were as important as they were far reaching in their results. His first efforts were directed towards the perfection of methods of "*preparing, welding, and working various sorts of iron, and of reducing the same into use by machinery, a furnace, and other apparatus adapted and applied to the said process.*" He made iron for "large uses," such as shanks, arms, rings, and palms of anchors, by piling and faggotting, bars of iron of suitable lengths being laid over one another in the same way as bricks in a building. The faggots were then placed in a common air or balling furnace and brought to a welding heat, and when the correct pitch of heat was reached they were brought under a forge hammer and welded into a solid mass.

Cort cleansed the iron and produced a metal of purer grain by passing the faggots through rollers. His method of manufacturing bar-iron from the ore, or from cast iron, presented a skilful combination of the various practices in general use before his day. Smiles succinctly describes his procedure:—"*The bottom of the reverbatory furnace,*" he says, "*was hollow, so as to contain the fluid metal introduced into it by ladles, the heat being kept up by pit coal or other fuel. When the furnace was charged, the doors were closed until the metal was sufficiently fused, when the workman opened an aperture and worked or stirred about the metal with iron bars, when an ebullition took place, during the continuance of which a bluish flame was emitted, the carbon of the cast iron was burned off, the metal separated from slag, and the iron, becoming reduced to nature, was then collected into lumps or loops of sizes suited to their intended uses when they were drawn out of the doors of the furnace. They were then cut into plates, and piled or worked in an air furnace, heated to a white or welding heat, shingled under a forge hammer, and passed through grooved rollers.*"

Cort, a native of Lancaster, benefited little by the results of his inventive genius. His partner proved untrustworthy, manufacturers unscrupulously availed themselves of his misfortunes to infringe his patents. He himself was reduced to penury, but during the last years of his life his circumstances were mitigated by a pension £200 per annum from the Lords of the Treasury.

It is a tribute to Cort's prescience that, though somewhat modified here and there, his processes have in the main successfully withstood the most searching tests of time. James Watt seems to have had doubts as to the exact quality of the iron produced by Cort's process, but he had no doubts with regard to the ingenuity of the inventor. Writing in 1784 to Dr. Black he said: "*Though I cannot perfectly agree with you as to its goodness, yet there is much ingenuity in the idea of forming the bars in that manner, which is the only part of his (Cort's) process which has any pretensions to novelty.*"

Midland ironfounders benefited in common with others from James Beaumont Neilson's discovery of the hot blast which Fairburn declared "*effected an entire revolution in the iron industry of Great Britain and forms the last era in the history of this material.*"

The essential principle of the invention was the passing of air through the tubes or passages of iron or fire clay heated by a flame or hot air surrounding them. The heat was obtained by utilising the profuse inflammable gases that formerly blazed to waste from the top of the blast furnace. The economy of fuel achieved by this means was tremendous. It rendered possible the use of coals of inferior quality for the purposes of iron manufacture. Not only so, but by lowering the cost of production, it infused new life into the industry, lessened unemployment, and increased the wealth and resources of the iron districts to an extraordinary extent.

A Mould-Making Discovery.

Delving among the records of the past one comes across many evidences of the shrewdness and inventive genius of the men who laid the foundation of the foundry trades, in directions other than those upon which their fame is generally considered to rest. Abraham Darby, for instance, laid the foundry trades under tribute of gratitude by solving the secret of mould making. The first moulds for his iron pots were made of clay, and they cracked and burst. After diligent inquiry he substituted moulds of fine dry sand for clay, and achieved success.

Early Discoveries in Steel.

David Mushet, while engaged in experiments for quite different purposes, discovered the certain fusibility of malleable iron at a suitable temperature, and other examples in which inventors were helped by what may be described as "accidents of chance" will no doubt be readily recalled. David Mushet was responsible for the preparation of steel from bar iron by a direct process combining the iron with carbon, and also, among other things, for the discovery of the beneficial effects of carbide of manganese on iron and steel, the use of carbides of iron in the puddling furnace in various modes of appliance, and the production of pig-iron from the blast furnace suitable for puddling without the intervention of the refinery.

Out of the wealth of discovery and invention, coupled with the incidental growth of machine making, necessitating a higher quality of work than had hitherto been attained, grew the idea of the cupola, which owed its invention to John Wilkinson. By means of the cupola, the principle of the blast furnace is adapted to the remelting of pig-iron. The reverberatory of air furnaces of those early days produced a hard but somewhat brittle casting, but there was a demand for a metal which was less liable to break, and this the cupola, provided with engine blast, proved capable of supplying to perfection. The solution of this problem solved also the difficulty of the makers of machine parts, and, to a large extent, that of makers of hollow ware, for whose purposes hard brittle material obviously is valueless. The mention of hollow ware serves as a reminder of the fact that this important industry was wrested by the Midlands from Wandsworth, in Surrey, although one local firm—Messrs. Izons & Company—now in West Bromwich, claims to be the oldest makers of cast hollow ware in the world, their works having originally been established in Birmingham in 1763. It was probably this factory which contributed most of all to the consolidation of trade in the Midlands.

There is no need to dwell upon the effects upon the iron industry of the introduction of Watts' steam engines, much less upon the more modern changes introduced into the foundry, forge, and engineering shops through the improvements effected in manufacture by Sir Henry Bessemer's process for the production of mild steel, which was patented in 1856. This process has a rival in the "Siemens-Martin" method of steelmaking, which is even more extensively used.

What stands out most clearly in all these things is the continuity of invention through the centuries since the epoch-making discoveries, and heart-breaking struggles, of the great pioneer of the Midland iron foundry trades—Dud Dudley. In the history of the iron trade the hour always seems to have produced the man, and the latest discoveries and improvements in processes of production, embodying the triumph of the puddler, backed by advanced scientific knowledge, impart a very satisfactory sense of completeness to what is in the fullest sense of the term a great industrial romance, the evolution of the iron trade.

Midland Firms.

In the heyday of iron-trade prosperity there were 171 blast furnaces in South Staffordshire and East Worcestershire. Of these, 24 were situated at Wolverhampton, 3 at Willenhall, 25 at Bilston, 14 at Wednesbury, 26 at Tipton, 13 at West Bromwich and Oldbury, 19 at Walsall, and 47 west of Dudley. In addition there were at Wolverhampton 260 puddling furnaces, with 39 mills and forges; Bilston, 238 puddling furnaces, with 47 mills and forges; Willenhall, 15 puddling furnaces, with 3 mills and forges; Wednesbury, 210 furnaces, with 28 mills and forges; Walsall, 136 furnaces, with 68 mills and forges; Tipton, 172 furnaces, with 47 mills and forges; and Dudley, 131 furnaces, with 13 mills and forges. These figures will afford a good idea of the tremendous industrial activity that prevailed, and it requires little exercise of the imagination to conjure up visions of the combination of smoke and flaming furnace which greeted and, in many cases, startled the stranger.

Bradley and Foster.

While he lived, John Wilkinson was the uncrowned kind of this iron kingdom, but no record of the coal and iron trades of the Midlands would be complete without reference to Reid, Parker, the Addenbrookes, Samuel and John Fereday, Firmestone, and Foley, amongst others, who played a by no means insignificant part in the early iron-making developments. Many memories, too, cluster round the name of James Foster, who became associated with the works of John Bradley & Company, of Stourbridge, established by his uncle John Bradley. Bradley's supplied nail rods to the nailers of Stourbridge, Wordsley, Brierley Hill, Dudley, Sedgeley, and Wolverhampton. At first, the nail makers were accustomed to send their carts to the works for the iron, but Mr. Foster altered this arrangement, delivering the iron in horse wagons, and settling the accounts quarterly. It was through this innovation on the part of Foster that the Ironmaster's Quarter Day originated, and it led eventually to the establishment of the Iron Exchange.

Under the able supervision of Foster, Bradley's developed rapidly. A man of great acumen and enterprise, it is said of him that he never hesitated to put his hand to a bar of iron in case of need. One of his most successful ventures was the purchase of the Madeley Court Estate, Shropshire, overlying seams of the best coal and ironstone in Salop. Here he smelted the ore into pig-iron for use at the Stourbridge works. Foster joined John Baker and George Jones in establishing the great Chillington works. He remained a partner in the concern till his death, when his interests were inherited by his nephew, W. O. Foster, a member of Parliament, who thoroughly maintained the family reputation for the production of first-class iron. In addition to the parent establishment at Stourbridge, W. O. Foster carried on mills, forges and blast furnaces at Shutt End and Madeley Court, and malleable ironworks at Brockmoor and Brierley Hill.

Another name well known in the industry in those great days was that of Philip Williams, who erected the Wednesbury Oak Works, comprising three furnaces, with extensive mills and forges, which, when in full working order, were regarded as the most complete of their type in South Staffordshire.

XUM

A Fortune for Puddled Iron.

At the close of the eighteenth century John and Edward Bagnall, natives of Broseley, and primarily mine owners, launched into iron-making at the Golds Hill Iron Works. On the death of Edward Bagnall, John took his brother's son into partnership, and, under the title of John Bagnall & Sons, the firm gave its name to a brand of iron which was justly famed wherever iron was known throughout the entire world.

The Addenbrookes turned out many excellent iron-makers, but none better than George and Edward Thorneycroft, who established the Shrubbery Works at Wolverhampton, where they made their famous bullet iron, which was in great request among the Lancashire cotton-machine makers. For some time the Thorneycrofts also carried on the old Bradley Works originally belonging to John Wilkinson, and later on they acquired and greatly enlarged Swan Garden Works.

The Sparrow family brought fame to the Stow Heath Furnaces and Bilston Mill. At the former Wm. Hanbury Sparrow made a huge fortune, amounting to between £1,300,000 and £1,500,000. The specialities of the Bilston Mill were rods, bars and hoops. The works were carried on for many years under the name of W. & J. S. Sparrow.

Another leading house, well known throughout the trade, was the New British Iron Company, which ran the Corngreaves works and works at Brierley Hill, comprising no less than 64 puddling and six blast furnaces. The iron manufactured by this firm is said to have been known at all the smithies and engine shops in Europe.

The Addenbrookes worked the Moorcroft concern in John Wilkinson's time, and they also ran three blast furnaces at Rough Hay. They patented a process of drawing off the gas which is said to have eclipsed all other methods. William Ward & Sons and New Priestfields turned out a first-class forge iron, but no works in their day were better equipped than the Earl of Dudley's celebrated malleable ironworks, situated at Round Oak, Brierley Hill, with 54 puddling furnaces. These forges were regarded as the model works of the Black Country, and, indeed, no effort was spared to render their technical efficiency complete.

A Record Puddling Plant.

The record for the largest number of puddling furnaces at one establishment in Staffordshire—one hundred—was held by W. Barrows & Sons, proprietors of the Bloomfield Factory and Tipton Ironworks. The capacity of the concern totalled 1,000 tons of finished iron per week.

Just about a century ago the firm of Bradley, Barrows & Hall enjoyed considerable repute in the iron trade, and the same thing may be said of Earl Granville's forge at Lilleshall. Many of the old ironmasters and founders were rough, hard and uncultured men, but notable exceptions were provided in the case of William Dawes & Sons the proprietors of the Bromford Ironworks, situated near the Oldbury Station. The Dawes family were gentlemen, born and educated. They exported nail rods in large quantities to China. Besides their Oldbury Works, the firm had two blast furnaces at Withymoor, near Dudley.

Roundabout 1853, a method of puddling iron with steel of a kind particularly well suited for the needs of the Sheffield cutlers was discovered in Staffordshire, and amongst the first makers were Messrs. Solley and Leabrook. The Chillington Company, by the way, were also quick to grasp the possibilities of this trade and developed it with marked success. At the same time Isaac Jenks commenced production at the Minerva and Beaver Works at Wolverhampton. Jenks was a man of unusual gifts, who commenced business with the slenderest means and eventually established himself as one of the wealthiest ironmasters in Wolverhampton. He carried his "Minerva" brand of steel into all markets.

Oldest Steelmakers.

The reputation of being the oldest steelmakers in Staffordshire is claimed by Messrs. William Hunt & Sons, of the Brades, Oldbury. Their plant comprised seven puddling furnaces with three mills, with extensive converting ovens on the old Sheffield plan.

The Darlaston Steel and Iron Company took to the old establishment of Bills and Mills, and built up a considerable connection for iron and steel. The Lloyds of Wednesbury, whose association with the staple industries of the community was as long as it was honourable, held a large interest in these works, which were situated at Darlaston Green.

An Ancient Welfare Effort.

It was Samuel Lloyd, perhaps the most famous member of the family, who built the old Park Works at Wednesbury, being joined by Foster. The firm, which was known as Lloyds, Foster & Company, possessed foundries with machine equipment which challenged comparison with anything to be found either at Manchester or on the Tyne. Lloyds, Foster & Company built the beautiful Blackfriars Bridge. Their works were colloquially known as "Quaker" Lloyds, and jobs there were greatly sought after by local workmen. Samuel Lloyd was the embodiment of beneficence. A 'truck" shop (still existing) was connected with the works, and it was known near and far for the superior quality of the goods stocked. The best butcher's meat in Wednesbury, it used to be said, was sold there. Old Samuel Lloyd took a special pride in buying the tea, the bullocks and the sheep himself, and it is related that he often walked up to the shop and looked over it.

Influence of Large Units.

About 1866 Old Park Works were emerged into a limited company called the Patent Shaft and Axletree Company, one of the largest concerns in Staffordshire, which is still flourishing. Wednesbury is also known, by the way, as the centre of the gas-tube trade. James Russell & Sons were the original patentees. In 1824 Messrs. T. & J. Roberts established the Great Swan Foundry at West Bromwich, which speedily won celebrity both for pipes and machinery.

Thomas Wells set up 22 puddling furnaces and three bar and plate mills at the Moxley Iron Works, and another eminent firm, Marshall & Mills, of the Monway Works, Wednesbury, were reputed to be the makers of the best gun-barrel iron in the world. For years they supplied the iron to the Birmingham gun makers and to the British and American Governments. Henry Mills erected a modern concern, unique of its kind, in the Victoria Works, at Walsall, and the record of the old ironworks and workers may fittingly be completed by mention of the names of the Mars Ironworks, Priestfields, Wolverhampton; the Horsley Company, at West Bromwich, and Wright & North's Monmoor Works.

In recent years the conditions of industry in the Midlands have been transformed. The glare of the hundreds of blast furnaces has to a large extent disappeared, but it does not necessarily follow that the output has been reduced. It has been earlier mentioned that the output, for instance, from a single modern blast furnace in one month is almost equivalent to the total output from all the blast furnaces of the country 200 years ago. The invention of the cupola by John Wilkinson was apparently quickly followed by the erection of new foundries and commencement of new businesses in the Black Country and surrounding districts. It is extremely difficult to obtain reliable information as to the establishment of many of the works, and particularly their subsequent history.

Foundry Establishments.

The foundry of Izons & Company was established in 1763 as "Izon, Whitehurst & Izon" at Duke Street, Birmingham. They were brass and general ironfounders, and the goods manufactured at that time—according to an old catalogue—consisted chiefly of humane man-traps, rat-traps, door-knockers, kitchen-stoves and other household utensils. This business continues to flourish, and it is interesting to note that the present chairman of the company is the great-great-grandson of the founder of the business.

Some 30 years later, in 1791, Archibald Kenrick commenced business as an ironfounder in West Bromwich. The purpose of the foundry was to make articles which were in daily use and constant demand, his principal manufactures being hand-mills for grinding coffee, and cast-iron saucepans. These are still being made in the factory, although many hundred additional articles of manufacture have been introduced. A few years later, about 1794, there was established a foundry at Stourport; the manufactures were somewhat similar to those of Archibald Kenrick. This business is still carried on under the name of Baldwin, Son & Company, being a subsidiary of Messrs. Archibald Kenrick & Sons. In the year 1795 a foundry was established in Wolverhampton by Wm. Clark, and this business is still in existence under the style of T. & C. Clark & Company.

Swan Garden Ironworks.

It has not been possible to obtain definite information, but it is believed that the Swan Garden Ironworks, which for the last 50 years have been carried on by Messrs. John Lysaght, Limited, were one of the original foundries belonging to John Wilkinson. Between the time of Wilkinson and Lysaght the works were carried on by G. & B. Thornycroft, as has already been mentioned. Early in the last century a works was established in Deepfields by Edward Sheldon & Company, also for making cast-iron hollow-ware. These works are still in the hands of the descendants of the Sheldon family, and are now known as the Cannon Ironfoundries, Limited. Mention has already been made of the Coalbrookdale works, which, of course, is still in existence, and also of Boulton & Watts' Soho Foundry, which, as generally known, is now incorporated in the works of Messrs. W. & T. Avery, Limited.

Sufficient has been stated already for it to be gathered that the iron trade in the Midlands has passed through many vicissitudes, with their records of sweeping industrial changes and upheavals. It is therefore an extremely gratifying reflection that many of the old works have stoutly and successfully maintained their positions in the van of progress. The foundries referred to are still conspicuous in the foundry world, and the works are as famous as ever for the quality and variety of their productions. The iron and steel trade and ironfounding in the Midlands has had a wonderful history, the last chapter of which has by no means yet been written.

If this attempt at a brief *résumé* of the iron and steel trades in the Midlands, disjointed though it is, serves no other purpose than to bring to mind some of the almost insuperable difficulties with which our forebears had to contend, it may have served a useful purpose.

Contracts Open.

Dartington, Devon, April 18.—654 yds. of 3-in. cast-iron water pipe, for the Totnes Rural District Council. Mr. W. F. Tollit, surveyor, 6, Bridgetown, Totnes.

Dublin, April 23.—Three electric overhead travelling cranes and gantries, for the Dublin Port and Docks Board. The Engineer's Office, East Wall, Dublin.

Sofia, Bulgaria, April 26.—40 locomotive watering standposts, for the Ministry of Railways, Sofia. The Department of Overseas Trade. (Reference A.X. 7661.)

"The Shear Test" not a Satisfactory Test for Cast Iron.

By W. Jolley.

(*Continued from page* 248.)

Table I shows the chemical analysis of the test-pieces. There is not a large variation in the chemical compositions, although there is a large variation in the physical results. These are due to the method of producing steel-mixtures and cupola conditions. It is clearly understood that although cast irons may have similar chemical analyses the method and materials used in production control its physical properties. It is the writer's opinion that by utilising the test-piece for the shear tests any variables of structures, etc., are entirely eliminated.

Table II shows the $\frac{\text{Shear}}{\text{Tensile}}$ ratio for both the 0.5-in. dia. and 0.22-in. dia. tests. In considering these results it appears that the $\frac{\text{Shear}}{\text{Tensile}}$ ratio is inversely proportional, and when the ratio is stated by other investigators it would assist if the lowest and highest tensile tests were stated, as these control the range of the ratios, also the ratios to be quoted as $\frac{\text{Shear}}{\text{Tensile}}$ so that various investigators' results can be readily compared and made uniform. A relation of Tensile to Shear chart is shown in J. W. Bolton's[12] Paper and is reproduced in Fig. 5. This shows a ratio of 1.19 to 1.73. Therefore, it appears that the question of shear test being equal to tensile test for cast iron, as suggested by the originators of the shear test, is not correct, and it is definite that the $\frac{\text{Shear}}{\text{Tensile}}$ ratio is not constant for both low tensile and high tensile iron.

Regarding the relation between shear, tensile and transverse, variations occur with different compositions and structures, and no formula will apparently convert one into the other unless one is working with a similar composition and section of casting.

Table I.—*Shear Relationship to Tensile and Chemical Analysis.*

Bar cast 1 in. square and machined to 0.5 in. dia. for tensile testing. Afterwards the tensile test bar was machined and used for the shear tests.

Test No.	0.5-in. Shear Stress. Tons/ sq. in.	0.22-in. Shear Stress. Tons/ sq. in.	U.T.S. Tons/ sq. in.	G.C.	C.C.	Si.	Mn.	S.	P.
1	16.8	8.1	9.8	2.85	0.59	1.56	0.68	0.110	0.64
2	22.6	17.6	14.0	2.90	0.56	1.84	0.71	0.103	0·63
3	16.2	15.7	10.0	2.90	0.56	1.60	0.65	0.114	0.48
4	23.0	20.0	13.8	—	—	—	—	—	—
5	18.0	16.2	16.7	2.75	0.60	1.68	0.65	0.117	0.56
6	20.3	20.0	14.3	2.75	0.62	1.49	0.66	0.117	0.48
7	—	27.7	22.0	2.25	0.66	1.24	0.73	0.117	0.54
8	—	25.5							
9	23.6	21.6	16.1	—	—	—	—	—	—
10	19.9	—	13.5	2.95	0.49	2.03	0.72	0.089	0.86
11	25.8	26.0	17.9	2.30	0.58	1.75	0.71	0.117	0.62
12	22.9	—	16.8	2.80	0.55	1.82	0.76	0.110	0.61
13	21.0	18.8	12.6	2.80	0.52	1.87	0.74	0.103	0.78
14	18.2	—	11.4	3.10	0.53	2.06	0.74	0.110	0.90
15	26.6	25.2	20.4	—	—	—	—	—	—
16	23.1	22.0	15.9	2.55	0.57	1.91	1.24	0.103	0.76
17	27.2	—	20.4	—	—	—	—	—	—
18	21.6	20.9	15.5	2.65	0.58	1.14	0.72	0.124	0.60
19	23.6	—	15.8	—	—	—	—	—	—
20	24.2	24.9	18.7	2.35	0.63	1.73	1.26	0.131	0.54
21	21.6	22.1	14.7	3.05	0.56	1.48	0.65	0.120	0.59
22	22.6	19.8	13.3	2.95	0.62	1.40	0.75	0.113	0.70
23	20.4	21.1	13.7	2.90	0.62	1.45	0.70	0.110	0.44
24	20.7	20.7	13.6	2.95	0.58	1.54	0.70	0.110	0·69
25	21.7	21.9	13.1	2.25	0.55	1.80	0.80	0.110	0.73
26	19.2	18.0	12.7	2.95	0.62	1.40	0.63	0.120	0.73
27	18.8	19.0	12.3	2.90	0.62	1.47	0.71	0.117	0.74
28	24.7	23.3	16.6	—	—	—	—	—	—
29	18.8	19.1	12.0	2.80	0.58	1.63	0.76	0.117	0.58
30	20.4	19.6	14.9	2.90	0.53	1.98	0.74	0.110	0.61
31	19.0	20.0	13.2	3.00	0.62	1.52	0.76	0.117	0.55
32	19.8	19.7	13.4	2.85	0.62	1.52	0.70	0.110	0.52
33	20.3	19.3	13.9	2.80	0.60	1.49	0.76	0.117	0.63
34	20.0	18.9	13.4	2.80	0.63	1.49	0.71	0.113	0.64
35	18.6	19.1	18.8	2.85	0.58	1.63	0.72	0.116	0.76
36	21.8	21.4	15.3	2.90	0.53	1.96	0.80	0.093	0.73
37	20.1	19.6	13.0	2.90	0.53	1.96	0.80	0.093	0.73
		20.1 from large section of casting.							
		20.6 „ „ same „							
		23.1 „ small „ „ „							
		21.9 „ „ „ „							
38	27.0	26.9	18.1	2.80	0.56	1.91	1.20	0.103	0.58
39	17.9	18.0	12.2	2.90	0.58	1.66	1.76	0.103	0.74
40	20.1	18.7	13.7	2.75	0.61	1.52	1.80	0.107	0.66
41	18.9	19.2	12.5	2.80	0.62	1.40	0.77	0.117	0.68
42	24.3	23.8	16.4	2.80	0.58	1.63	1.25	0.113	0.59
43	18.6	16.7	14.4	2.70	0.60	1.54	1.03	0.117	0.68
44	20.4	18.8	13.9	2.80	0.56	1.70	0.76	0.110	0.80
45	24.8	24.1	15.9	2.25	0.73	1.40	0.72	0.117	0.54
46	21.5	20.9	15.2	2.85	0.56	1.87	0.68	0.103	0.80
47	21.1	19.6	14.5	2.80	0.62	1.40	0.78	0.117	0.69
48	21.0	19.6	14.4	2.85	0.62	1.54	0.76	0.117	0.69
49	17.8	17.8	11.3	2.85	0.57	1.66	0.77	0.117	0.69
50	24.5	23.0	17.6	2.75	0.60	1.47	0.76	0.120	0.51
51	18.2	16.4	10.9	2.90	0.51	1.93	0.76	0.103	0.58
52	23.9	22.2	13.7	2.20	0.64	1.75	0.92	0.110	0.64
53	18.9	18.6	12.3	2.80	0.58	1.47	0.79	0.106	0.56

Table II.—*Shear Relationship to Tensile.*

Shear 0.22 in. Dia.

Bar cast 1 in. square and machined to 0.5 in. dia. for tensile testing. Afterwards the tensile test bar was machined and used for the shear tests.

10.5 tons tensile	1.61 ratio	17.0 tons shear
13.5 „ „	1.47 „	20.0 „ „
16.5 „ „	1.39 „	23.0 „ „
19.4 „ „	1.34 „	26.0 „ „
21.3 „ „	1.31 „	28.0 „ „

Shear 0.5 in. Dia.

Bar cast 1 in. square and machined to 0.5 in. dia. for tensile testing. Afterwards the tensile bar was used for the shear tests.

9.5 tons tensile	1.84 ratio	17.0 tons shear.
12.5 „ „	1.60 „	20.0 „ „
15.5 „ „	1.47 „	23.0 „ „
18.5 „ „	1.40 „	26.0 „ „
20.5 „ „	1.37 „	28.0 „ „

These ratios are from the curves plotted from over 150 tests.

Although the writer has not fully completed his investigations on cast irons of large chemical variations and different cooling rates, it appears that high shear test values can be obtained with irons that give low transverse and deflection tests.

Varlet,[13] in his experiment, shows the necessity for making test-pieces to correspond, so far as is practically possible, with the average thickness of the casting as is now specified in the B.E.S.A. Specification "A" and "C" for grey iron castings. The test he had taken from a block of varying thicknesses gave tests that varied from 23.2 to 36.9 kilos in the same casting.

Table III.—*Tensile Test taken from Block as shown in Fig. 6.*

Position.	*U.T.S. per sq. in.*
Between 1 and 2	10.6
„ 3 and 4	11.2
„ 5 and 6	9.1
„ 7 and 8	9.0

Tensile specimens were cut from casting at right angles to direction in which shear tests were taken.

Siegle[14] insists that single shear give best results. In the very grey irons, the large flakes of graphite constitute zones of weakness, the effect of which would become exaggerated on bars of small section, and would lead to a totally wrong idea of the transverse or tensile test of this iron. Oberhoffer and Ponsger[15] give a striking example of the effect of graphite on bar size. They cut a slice 2.5 in. wide from a 2-ft. square block, and cut bars 5, 10, 15, 20 mm. from this homogeneous piece. The small bar gave no transverse value, the 10-mm., 25 k.; the 15-mm., 27 k.; and the 20-mm. gave 32

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[1] A.F.A. Proceedings, May 14—18, 1928, page 487.
[2] A.F.A. Proceedings, 1926.
[3] A.F.A. Proceedings, 1912, page 635.
[4] I.B.F. Proceedings, 1921-22.
[5] I.B.F. Proceedings, 1922-23.
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[9] A.F.A. Proceedings, September 27, 1926. Testing of C.I.
[10] Die Giesserei, August 14 and 21, 1926. 13594.
[11] Communicated Results.
[12] A.F.A. Proceedings, May 14, 1928.
[13] I.B.F. Proceedings, 1922-23.
[14] I.B.F. Proceedings, 1922-23.
[15] Stahl v. Eisen, August 3, 1922.
[16] I.B.F. Proceedings, 1926-27.

k/mm. This has nothing to do with the cooling effect on bars cast of different sizes, but only refers to the effect of graphite on different size bars cut from the same material.

Audo[15] cast bars on cylinders equal in thickness to casting. From these he cut Frémont, transverse and shear tests. He states that the formula is only applicable to stated mixtures.

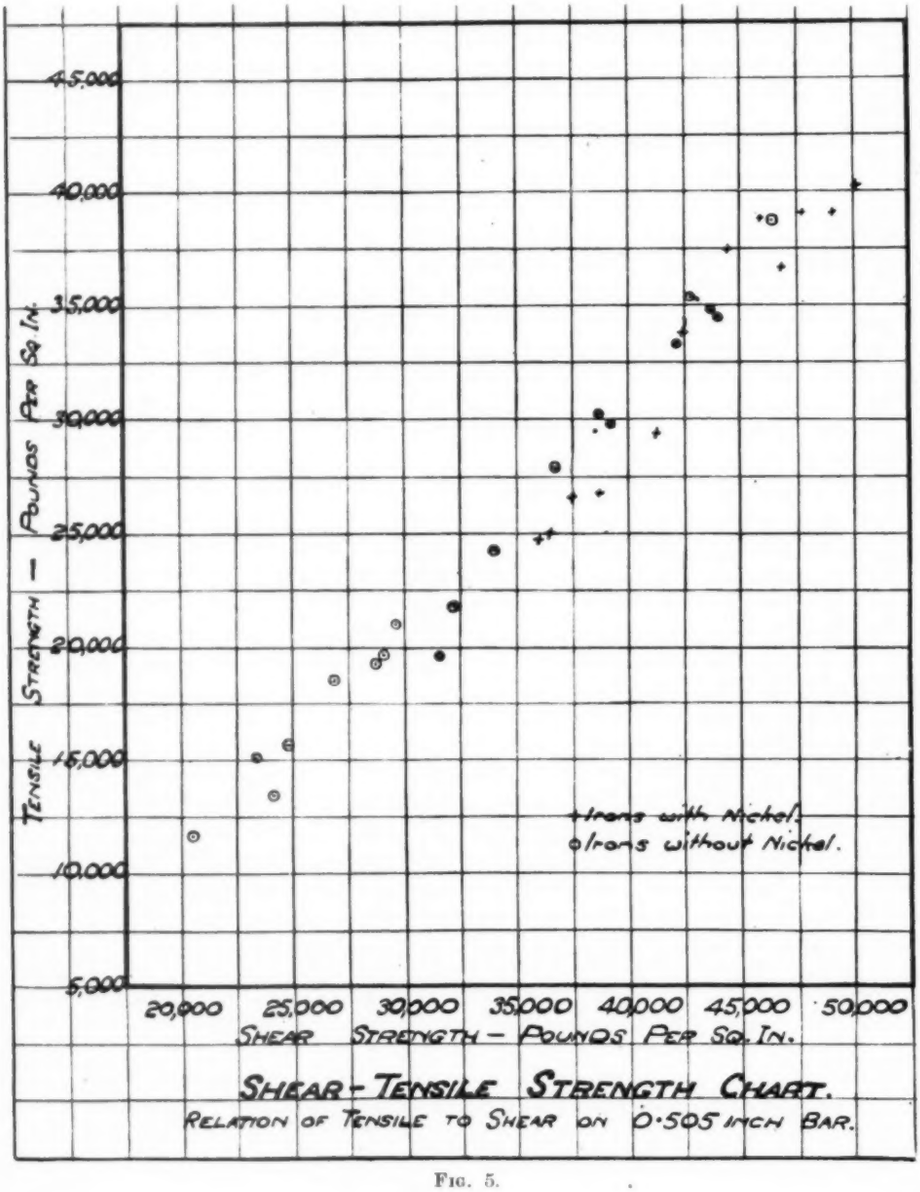


Fig. 5.

To test the variation that can be met with in one casting, the writer cast the block as shown in Fig. 6. In a casting having the variations in section similar to this it would be very difficult for the engineer and foundryman to agree from where to take the test-pieces to obtain a representative sample, and when one considers the complicated castings that are made, the clauses that would be necessary in a shear test specification to make it workable would be tremendous.

Table III shows the tensile test results of pieces taken from positions between 1 and 2, 3 and 4, 5 and 6, 7 and 8, of Fig. 6.

Without considering the metallurgical points of the governing factors that the structure, size and distribution of the graphite flakes have on the strength of cast iron, it is an accepted fact that generally cast iron which exhibits large coarse flakes is weaker than that with fine, curly graphite flakes if other elements remain equal.

It is therefore apparent in the various unetched microstructures of the different sections of the block, Fig. 6, a large variation in the graphite size and the weakness of these large graphite flakes on the metal is borne out by the variation in the shear and tensile test results taken at different points.

Conclusions.

A general conclusion may be drawn from these notes in regard to tensile and shear tests. The tensile test, which is a test of the structure of the metal, has been considerably misrepresented. There is no doubt that satisfactory and uniform results can be obtained when the tests are carefully conducted. If the foundryman has a specification that includes transverse, tensile and deflection tests, then to meet this combination he is forced to make the casting from a high-class metal, and that is what is required by engineers.

The present shear test methods do not appear to give uniform results, also the $\frac{\text{Shear}}{\text{Tensile}}$ results of different investigators vary considerably, which indicates the unreliability of this test, and to suggest this as a standard test for cast iron would result in utter confusion so far as figures put forward from the shear test to represent the tensile test cannot be fully agreed upon.

The method of obtaining the test-pieces gives a surface that would not be satisfactory for consulting engineers; also in calculating the results from a trepanned test-piece 0.005 in. out of round would not be advantageous to the metal, as the size would be taken at the largest diameter.

Unless satisfactory testing apparatus and test-pieces—machined true to size—are used, it appears that it is impossible to avoid a bending strain during testing, which would give false results.

No regular relation has been found to exist between shear and transverse tests, but apparently the transverse test is universally accepted as one of the standard tests for cast iron.

The tensile test, in conjunction with the transverse, deflection and hardness tests, appear to be the most satisfactory method of obtaining the quality and structure of cast iron used for the manufacture of general castings. A small test-piece 0.22 in. dia., as suggested for the shear test, is out of all proportion for representing the quality of the metal, etc., in castings similar to those shown earlier in this article.

A Contribution by Mr. John Shaw to the Study of Shear Testing.

In view of the approaching Internation Foundrymen's Convention, Mr. Jolley's Paper on the above subject is both opportune and needful. Owing to the engineers of this country not being in favour of the "Shear" test, the I.B.F. Test Bar Committee had devoted little time to the subject. The danger (due to persistent propaganda in some of the Exchange Papers) that this form of test might be put forward as the basis for an "International Standard," made it imperative that a searching examination of its possibilities should be carried out. The more so as this country, as one of the largest exporters, would be vitally affected. Although the Committee have not yet finished their work, the following figures will no doubt create interest in the question and lead to independent trials.

At present the transverse and/or the tensile test is accepted in France, America, Germany and Britain as the most reliable test for cast iron. Many thousands of tons are passed yearly on the results of these tests alone, so far as the physical properties of the metal run into the castings. No test, unless it be one of the complete casting itself under test conditions, will locate hidden flaws. Will the "Frémont" tests give us more information, or will it give reliable data of the many compositions found in such castings as pipes, columns, bedplates, keel blocks, etc., all of which are now satisfactorily passed for physical properties of the metal by the transverse test? What claims are made for this shear test? The test seems so ideal (drilling a small hole with a hollow drill and testing the small 0.22-in. dia. piece taken from the casting itself) that the snags are liable to be overlooked. Frémont states: "That the impact bending test does not indicate the strength of cast iron," "that the tensile test can never be performed with sufficient accuracy, whatever the care bestowed and the precision of the apparatus, since the test-piece can never be pulled in absolute axial direction" (both points open to discussion). "Static bending and shearing are the only mechanical tests capable of revealing the qualities of cast iron."[1]

[1] A.F.A., 1912, p. 636.

Ronceray states: "That Frémont and many others consider the transverse test is an ideal one." "Found that the shearing strength is proportional to the transverse strength. Other experimenters have shown that the tensile strength is equal to the shear strength for cast iron. *Consequently a shear test is quite satisfactory for inspection purposes.*"[2] Audo and Le Thomas both confirm that the shear results equals those obtained by tensile on the same metal.

How have these conclusions been reached? Frémont about 1909 took 140 bars collected from an important department; the tensile strengths were known. From the heads of these bars he cut out small prisms 8 × 10 × 30 mm., and subjected these to static bending tests on a small machine he had designed. From these results he plotted a graph, by which he found that two specimens of cast iron with equal breaking strength under statical bending tests may vary in tensile strength in some cases as much as 2:1. We are given no analyses of these bars, whether they varied in diameter as cast or turned, so it is impossible to reach any independent conclusion. A further series of tests were then made from 267 bars or castings, from the ends of which the small static bending piece of 8 × 10 × 30 mm. and also a shear piece of 5 × 5 × 20 mm. were cut. This time, as might be expected when testing small pieces from the same bar, sufficiently complete relation exists. The same can be said if one tests each half of a broken tensile test bar. Eight trials did not vary more than 0.5 ton from the results found on the original bars. In order to compare the results of shearing and impact, Frémont obtained 37 impact test-pieces of known values The impact bars were 40 mm. square × 200 mm. long. From these he cut two pieces 5×5×20 mm. from each bar, one in the middle, the other near the edge, for shear tests. His conclusion was: "That there is no relation between impact bending tests and the shearing or static bending tests." Again we are given neither analyses nor microstructure of these bars. From some of the results which follow, one would rather be inclined to trust the drop test as a criterion of the *quality* of the metal rather than the shear test.

Having now examined the history of this particular shear test, let us see how the following results uphold the claims made, Jolley has shown that any specimen that is simply trepanned out can never be true enough to give correct results. That with the small test-piece 0.22-in. dia., even when finished to dead size, the results would vary, due to the influence of the graphite on this small diameter. Both these points were raised by the American delegates, and the writer, at the informal meeting held in Detroit in 1926. M. Ronceray then made a strong plea that the *principle* of the shear test should be investigated, as distinct from the method of application. It is on these lines that much work has been done in this country during the last two years, and the sole issue has been: Will the shear test give as much reliable data to the inspecting engineer as the present transverse and tensile tests? Keeping in mind that on many jobs his only means of gauging the strength properties of the metal is derived from one or two simple tests obtained from bars either cast on the body or separate. He has neither analyses nor micros. Table I, collected by the writer, is arranged in increasing transverse modulus values. The first column names the source. The fifth, ratio when shear is divided by transverse modulus. The sixth column shows the actual difference between the modulus figure and the shear value. It is not generally realised what a difference a few decimal points in the ratio means. In this table there is a difference of from plus 7.6 tons to minus 19.8 tons. It will be noticed at once there is no fixed ratio between shear and transverse, but that it varies with composition, etc. It would seem also that a premium is placed on poor material by the shear test. From eight tests, personally made, with bars containing about 1.2 per cent. CC and 1.3 per cent. P the modulus figure was too low to pass the specification. Yet the shear test showed good results in each case. In order to verify this the writer asked several members to cast him some bars of a similar composition. This was done by putting extra charges on after the day's blow, as the composition was outside their regular mixture. Thanks are due to the gentlemen who helped to verify this important point. The bars are grey and, although hard, are machinable. Not one of the first nine bars reached 28 cwt. on the 2-in. × 1-in. × 36-in. centres test, and would not pass the material made from these irons. Yet if we are to use the figure often mentioned, viz., that the modulus is equal to about twice the shear, all these nine tests would be passed as excellent material by the shear results. A reference either to Jolley's figures or to Bolton's on his 1.2-dia. bars show the same tendency to give higher values to the shear with lower modulus. That the ratio of shear to static bending is not constant is borne out by Le Thomas' results.[3] Take the two examples L and M, both results taken from the 25-mm. dia. bar and, therefore, the same cooling rate. (See over-leaf.)

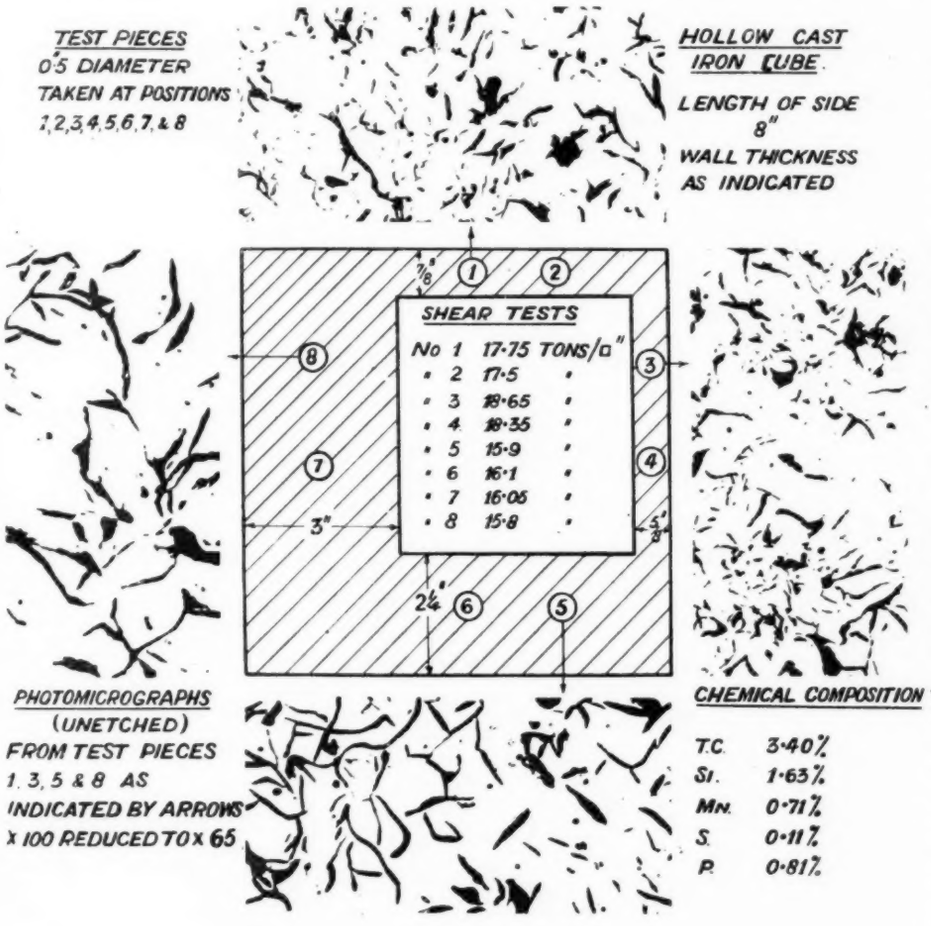


Fig. 6.

Table II is compiled on similar lines to Table I, but shows the shear in relation to rising tensile strengths. Again it would appear that the shear results put a premium on the poor material. The $\frac{\text{Tensile}}{\text{Shear}}$ value varies from 2.3:1 to 1:1. Cameron's bars are somewhat out of line, but this is due to using the S bar ¾-in. dia. as cast and testing for tensile at 0.564 in. and 0.5 in. for shear, the quick cooling of the small bar giving a less heterogeneous material. Also the shear and tensile are taken on practically the same diameter of bar.

Examining these results how can any inspecting engineer judge of the quality of the metal from the shear test alone? By what constant can he convert his shear value into tons per square inch tensile? If one discarded the transverse and tensile as advocated earlier in the paper, would the tons per square inch shown by the shear test give one confidence that the metal used was good quality, and so far as that portion of the inspection went would pass the material? Take the bar received from MacKenzie. This was sent to the writer for another purpose, and did not pretend to be good metal. It had chilled corners ⅛ in. deep. The bar, 2 in. × 1 in., when tested on the flat at 24-in. centres broke at 1,790 lbs. Yet on Jolley's shear machine it gave 26.4 tons shear strength. Is any further comment needed?

Much has been made of the fact that small pieces can be cut from the casting itself for testing. No one will deny the advantage of this, providing the results obtained are true, and that the piece taken represents the bulk of the casting. Besides the troubles already dealt with—ratio and composition—it often happens that the portions most liable to weakness cannot be drilled owing either to their position or the effect of replugging the hole on the wearing part of the casting. The question as to where the casting should be drilled would in many cases be a source of constant trouble between the firm and the visiting inspector. Elliot raised this point[4] stating "That it would seem that the location to be drilled for samples would have to be definitely stated." This fact seems to have been

[2] I.B.F., 1921/22, p. 37.

[3] A.F.A., 1926, p. 728, Table II. [4] A.F.A., 1926, p. 867.

realised in France, as is shown by authors of two good Papers[5] [6] "Cast bosses on the casting *where stated*, the dimension of which along the axis is a few centimetres, while the other dimension (cross section) was approximately the thickness of the casting." Through the courtesy of M. Le Thomas the author has appended a sketch (Fig. A). There are several objections to this method in addition to those already mentioned; for instance, there is (1) the danger of a drawn place at the root of the test piece when parted off, especially if the section is a thick one; (2) the disfigurement of the face of the casting; (3) the ease with which the structure of these bosses can be altered by an unscrupulous contractor—a chill on the face of the boss or flat-headed nails level with the face would give an entirely different structure from the rest of the body, and would be difficult to detect. What a difference to the result it makes where the test piece is taken from is shown in the two following examples:—Hyde sent four bars to the Sheffield Testing Company so as to obtain an independent test. The bars were 2 in. × 1 in. × 42 in. Two mixtures were used and two bars cast from each mixture, so as to avoid a failure in one bar. The three shear pieces from each bar were obtained, as shown in Fig. B, and measured $\frac{7}{16}$ in. dia., and were tested in double shear. The results are given in Table III.

	T.C.	Si.	Mn.	S.	P.	Shear.	St. bend.	Ratio.
L	2.92%	1.46%	0.77%	0.05%	0.2%	28 kg. mm.²	710 kg. mm.²	25.35 : 1
M	2.92%	1.3%	0.97%	0.04%	0.2%	22.6 kg. mm.²	800 kg. mm.²	35.4 : 1

A clear difference of over 30 per cent.

Pearce's results were taken from one bar, and show that at times what a vital influence the size of the test piece can have, though the discrepancy is not often so great, as shown in the present case. Any wear on the cutting edge of the shear blades also affects the results.

That where foundries are controlled, as are those mentioned by M. Le Thomas or M. Audo, with their multiplicity of check tests (from the raw material; cupola practice; remelted iron to have a homogeneous raw material; Brinell hardness; compression tests; full analyses and microphotos), one will under these circumstances have fairly concordant results. The shear, also the tensile or transverse tests, would give results which can be fully expected, but dare one say equally good castings can be produced if any single one of these tests were discarded? At the same time the writer, acting as an inspecting engineer, would never dare to pass work for physical strengths by the results obtained alone from the shear test.

The statements in this note are definitely provocative. If we are to have a paper on the shear test at the coming Convention, it is only fair to the author that these views are given now, so as to provide ample time for them to be rebutted, if that is possible.

Table I.—*Tests arranged in order of Transverse Strengths.*

Name.	Trnvse. Tns. mod.	Defn. in ins.	Shear. Tns.	Shear / Trnvse Tns.	Diffce. Tns.	T.C.	C.C.	Si.	Mn.	S.	P.
MacKenzie	14.4	—	26.4	1.83	+12.0	3.1	—	2.0	0.39	0.37	0.85
Hyde (2)	16.74	0.260	14.7	0.88	− 3.0	3.04	—	3.19	0.63	0.057	1.32
Wilson	16.87	0.307	22.8	1.35	+ 5.9	3.25	1.12	1.56	0.27	0.128	1.17
,, ...	17.75	0.346	23.7	1.34	+ 5.9	3.25	1.12	1.56	0.27	0.128	1.17
Hyde (2A)	17.71	0.274	15.2	0.85	− 2.5	3.04	—	3.19	0.63	0.057	1.32
,, (1A)	18.16	0.287	17.4	0.95	− 0.76	3.01	—	2.93	0.61	0.059	1.14
,, (1)	18.35	0.290	17.8	0.97	− 0.55	3.01	—	2.93	0.61	0.059	1.14
Wilson	18.69	0.361	22.7	1.21	+ 4.01	3.25	1.12	1.56	0.27	0.128	1.17
Marshall	18.78	—	26.1	1.38	+ 7.32	2.65	1.07	2.15	0.32	0.168	1.27
Jolley	19.72	—	18.9	0.96	− 0.82	3.38	0.58	1.47	0.79	0.106	0.64
,, ...	19.32	—	19.95	1.00	+ 0.63	3.44	0.49	2.03	0.72	0.089	0.86
Elliot	20.0	—	13.5	0.67	− 6.5	3.50	—	2.00	0.57	0.08	0.57
Rother	21.1	—	12.4	0.59	− 8·7	3.30	0.60	1.75	0.65	0.08	0.39
Cameron	21.17	—	13.67	0.64	− 7.48	—	0.28	—	—	—	1.00
,, ...	21.68	—	14.31	0.66	− 7·37	—	0.36	—	—	—	0.90
Jolley	23.45	—	20.0	0.85	− 3.45	3.51	0.61	1.61	0.72	0.10	0.74
Elliot	25.2	—	18.2	0.72	− 7.0	3.22	—	1.54	0.61	0.07	0.36
,, ...	25.6	—	18.4	0.72	− 7.2	3.16	—	1.50	0.56	0.06	0.56
B.C.I.R.A.	26.5	—	12.9	0.49	−13.6	3.41	0.77	1.75	0.51	0.08	0.55
Jolley	27.3	—	18.0	0.66	− 9.3	3.35	0.60	1.68	0.65	0.117	0.56
,, ...	27.13	—	17.9	0.66	− 9.23	3.36	0.56	1.91	1.20	0.103	0.58
B.C.I.R.A.	29.2	—	18.4	0.59	−10.8	3.17	0.87	0.68	0.67	0.156	0.166
Cameron	32.8	—	20.47	0.62	−12.33	—	0.70	—	—	—	0.50
,, ...	34.68	—	23.13	0.67	−11.55	—	0.95	—	—	—	0.50
B.C.I.R.A.	35.4	—	18.7	0.53	−16.7	2.03	0.72	1.39	0.87	0.04	0.157
,, ...	40.5	—	20.7	0.51	−19.8	2.03	0.72	1.39	0.87	0.04	0.157

Table II.—*Tests arranged in order of Tensile Strengths.*

Name.	Tensile. Tns.	Shear. Tns.	Shear / Tensile Tns.	Difference. Tns.	T.C.	C.C.	Si.	Mn.	S.	P.
B.C.I.R.A. ..	9.8	18.7	1.9	+ 8.9	—	—	—	—	—	—
Jolley	9.82	17.0	1.72	+ 7.18	3.44	0.59	1.56	0.68	0.11	0.64
,, ...	10.0	16.25	1.62	+ 6.25	3.46	0.56	1.60	0.65	0.114	0.48
Wilson	10.5	22.8	2.2	+12.7	3.25	1.12	1.56	0.27	0.128	1.17
Hyde	10.8	14.9	1.35	+ 4.0	3.01	—	2.93	0.61	0.059	1.14
Marshall ..	11.0	26.1	2.3	+15.1	2.65	1.07	2.15	0.32	0.168	1.27
MacKenzie ..	—	26.4	—	—	3.1	—	2.0	0.39	0.37	0.85
Wilson	11.7	23.7	2.0	+12.0	3.25	1.12	1.56	0.27	0.128	1.17
B.C.I.R.A. ..	11.7	20.7	1.77	+ 9.0	2.03	0.72	1.39	0.87	0.04	0.157
Cameron	11.7	13.69	*1.17	+ 1.99	—	0.28	—	—	—	1.00
,, ...	12.2	14.31	*1.17	+ 2.11	—	0.36	—	—	—	0.90
Jolley	13.2	20.0	1.52	+ 6.8	3.51	0.61	1.61	0.72	0.10	0.74
Hyde	13.6	18.2	1.34	+ 4.6	3.01	—	2.93	0.61	0.059	1.14
Jolley	15.5	21.6	1.4	+ 6.1	3.23	0.58	1.14	0.72	0.124	0.60
B.C.I.R.A. ..	15.7	19.2	1.22	+ 3.5	3.20	0.88	0.86	0.67	0.17	0.17
Elliot	16.0	18.2	1.14	+ 2.2	3.22	—	1.54	0.61	0.07	0.36
,, ...	16.4	18.4	1.12	+ 2.0	3.16	—	1.50	0.56	0.06	0.56
Jolley	16.4	24.3	1.42	+ 7.9	3.38	0.58	1.63	1.25	0.113	0.59
B.C.I.R.A. ..	17.0	12.9	0.76	− 4.1	3.41	0.77	1.75	0.51	0.08	0.55
,, ..	17.3	18.4	1.06	+ 1.1	3.17	0.87	0.68	0.67	0.156	0.166
,, ..	18.3	21.9	1.20	+ 3.6	3.15	1.44	0.63	0.50	0.12	0.36
Cameron	19.76	20.47	*1.04	+ 0.71	—	0.70	—	—	—	0.50
,, ...	20.56	23.13	*1.125	+ 2.47	—	0.95	—	—	—	0.50
Jolley	20.4	26.6	1.3	+ 6.2	—	—	—	—	—	—
,, ...	21.3	28.0	1.3	+ 6.5	—	—	—	—	—	—
Audo	16.7	18.9	0.96 to 1.2	—	3.0	—	1.5	0.65	0.10	0.20
Le Thomas ..	—	17.8	0.90 to 1.0	—	2.97	—	1.61	0.40	0.07	0.26

Table III.—*Shear Test.*

		No. 1. Tns.	No. 2.	No. 3.	Position.
Hyde's	Bar A (1)	18.6	15.4	19.5	Two bars in one box.
	Bar A (2)	18.1	15.8	18.3	
	Bar B (1)	14.9	14.3	14.8	Two bars in one box.
	Bar B (2)	16.1	14.5	14.9	
Pearce	Test 0.22″ dia.	12.6	11.65	13.4	Same bar.
,,	,, 0.59″ dia.	17.0	17.20	17.9	

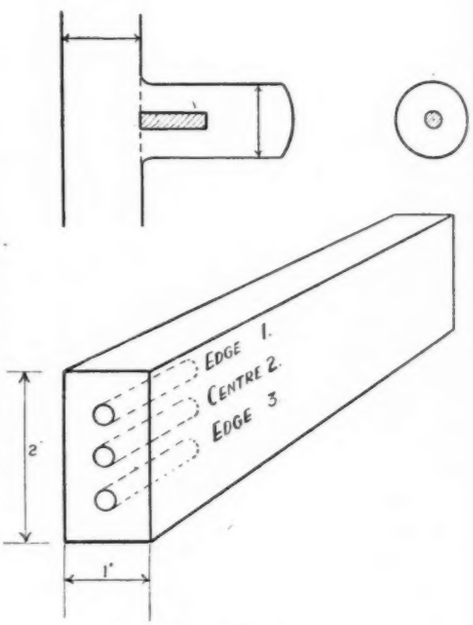


Fig. A (top).
Fig. B (bottom).

Dasco Steel.—A new line of alloy tool steels is being introduced by the Detroit Alloy Steel Company, Iron Street, Detroit, U.S.A., a new company. The new steel will have the trade name "Dasco." These steels, it is stated, comprise a number of different alloy combinations applicable to a wide variety of uses in the automotive, railway, steel, wire and other industries. They will be supplied in the form of castings and bars in almost any required sizes. Through air hardening to 1,650 deg. Fah., a maximum hardness is said to be obtainable without quenching. Dies made of Dasco steel, it is claimed, have shown unusual wearing qualities. They are said to be easily machinable and take a high polish. Dies of Dasco steel may be cast in one piece to intricate shapes, saving material and machining costs.—"The Iron Age."

[5] Audo, I.B.F., 1926/27, p. 140.
[6] Le Thomas, A.F.A., 1926, p. 705.

STANTON
PIG
IRON
THE STANTON
IRONWORKS
COMPANY LIMITED
NEAR
NOTTINGHAM

Trade Talk.

Messrs. Dorman, Long & Company, Limited, intend putting another blast furnace into operation at their Clarence Works.

The London offices of the Rotherham Forge and Rolling Mills Company, Limited, are now at 110, Cannon Street, E.C.4.

It is expected that Messrs. Palmers Shipbuilding and Iron Company, Limited, will shortly restart two of their blast furnaces.

The employees of Messrs. Fiat British Auxiliaries, Limited, Govan, have contributed the sum of £79 16s. to local hospitals.

The Ailsa Shipbuilding Company, Limited, Troon, and Ayr, have received a contract to build a single-screw cargo steamer for British owners.

Pneumatic Conveyance and Extraction, Limited, have removed from Rusholme, Manchester, to Broadway Buildings, 50-64, The Broadway, Westminster, London, S.W.1.

The Motherwell Dean of Guild have approved of the plans and granted lining for an extension to the Vulan Works, Flemington, of Messrs. Stewart & Lloyds, Limited.

The apprentice moulders employed at Messrs. Cameron & Roberton's, Southbank Foundry, Kirkintilloch, held a social and dance last week. Mr. John McEachern, chief foreman, presided.

The Northumberland Shipbuilding Company (1927), Limited, Howdon-on-Tyne, have secured an order from British owners for a vessel of 9,000 tons deadweight. The machinery is to be supplied by the North-Eastern Marine Engineering Company, Limited, Wallsend.

The Krupp Nirosta Company, Incorporated, of Wabervliet, New York, U.S.A., have purchased the three Johnson patents covering the analysis and manufacture of Rezistal corrosion and heat-resisting steel from the Crucible Steel Company, Incorporated, the latter having acquired an interest in the Krupp Nirosta concern.

The Standard Steel Company (1929), Limited, have acquired the business and undertaking of the Standard Steel Company, Limited, of 72, Purley Way, Croydon, as from March 1, 1929, and are carrying out all uncompleted contracts and orders for steelwork, machinery, etc. The company is putting in new and up-to-date machinery.

The directors of the Arizona Copper Company, Limited, Edinburgh, held a meeting on April 10 with a view to the company being put into voluntary liquidation. It is intended that a first dividend of 40s. per share should be distributed about May 31. The company's holding in the Phelps Dodge Corporation, of America, was sold recently.

Over 500 employees who struck work at the Normanby Park Works, Scunthorpe, of Messrs. J. Lysaght, Limited, as the result of a dispute over a question of seniority, have returned to work. Negotiations are to take place on the matter in dispute. The men, who are employed in the rolling mills and melting shops, struck work as a protest against the promotion of a certain man.

With a view to enhancing the safety of the employees and the avoidance of accidents, a "Safety First" Committee has been formed at the Southbank Iron Works, Kirkintilloch, of Messrs. Cameron & Roberton, Limited, with Mr. T. P. Cameron, chairman, and Mr. Wm. Edgar, secretary. A leaflet indicating important points for workers in relation to their own safety has been prepared and circulated.

A contract has been awarded to the British Thomson-Houston Company, Limited, Rugby, by the Municipal Council of Rotterdam, Holland, for 25,000-volt three-phase, 50-cycle switchgear required in connection with the new power station which is being erected three miles nearer the mouth of the Maas than the existing Schiehaven station, which has reached maximum capacity. The ultimate capacity of the new power station will be 252,000 kw.

From Clyde shipyards three vessels were launched on March 27. The twin-screw motorship "Cingalese Prince," of 10,000 dead-weight, by the Blythswood Shipbuilding Company, Limited, Scotstoun, for the Rio Cape Line, Limited, London; the twin-screw motorship "Rangitaka," 16,755 tons gross, by Messrs. John Brown & Company, Limited, Clydebank, for the Federal Steam Navigation Company, Limited, London; and the cargo steamer "Algonquins," 1,940 tons gross, by Messrs. Barclay Curle & Company, Limited, West Yard, Scotstoun, for Messrs. Boland & Scott-Misener, Sarnia, Ontario.

The Wellman Smith Owen Engineering Corporation, Limited, report the receipt of the following foreign orders:—Verreries Souchon Neuvesel, Lyons, two Wellman gas producers for their new glass-bottle plant at Puy-Guillaume, Haute Loire, France (repeat order); Evence Coppée & Company, Brussels, one combined coke-pushing, coal-levelling and door-extracting machine for the coke ovens at Anderlue, Belgium; Société Anonyme Ougrée-Marihaye, one combined coke-pushing, coal-levelling and door-extracting machine for the new battery of Koppers coke ovens (duplicate of the machine supplied in 1928).

There was a large output of new tonnage from the Clyde shipyards in the first quarter of this year. The total for March consisted of 22 vessels, of 75,520 tons, which was the largest on record for the month, and made an aggregate of 42 vessels, of 147,611 tons, for the three months. It is not expected that the activity of the past quarter will continue, as the tonnage on hand is decreasing. The prospects of the Tees shipbuilding industry are promising. The returns of two yards alone show a tonnage of 40,000 for the first quarter, while the tonnage of all yards for the whole of 1928 was 160,000. One yard has orders for 75,000 tons, and others are well booked up for the rest of the year.

Further shipbuilding orders for Great Britain from Yugoslavia, probably amounting to £1,000,000, and bringing the total since the war up to about £2,000,000, were forecast by Mr. B. N. Banaz, general manager of Messrs. Baburizza & Company, Limited, London, agents for the Yugoslav Lloyd, who has returned to London after visiting Belgrade. He said that the forthcoming Yugoslav Budget provided for a subsidy equivalent to £2,000,000, spread over 10 years, for maritime expansion on the Adriatic. The shipping companies would have to build several new steamers, and the bigger ones would certainly be built in British yards. It was likely that, of the £2,000,000, £1,000,000 would be spent in Great Britain during the next five or six years.

Reports and Dividends.

Richard Thomas & Company, Limited.—The preference share dividend due on March 31 has been passed.

Chesterfield Tube Company, Limited.—Interim dividend on the 7½ per cent. cumulative preference shares.

G. D. Peters & Company, Limited.—Net profit, £8,228; brought in, £7,724; to income-tax reserve, £1,200; carried forward, £14,752.

Smith & McLean, Limited.—Net profit, £23,601; brought in, £19,614; dividend on the ordinary shares of 7 per cent.; carried forward, £19,015.

Samuel Heath & Sons, Limited.—Profit, £5,878; brought in, £13,936; dividend of 10 per cent. on the ordinary shares, tax free; carried forward, £14,614.

Coltness Iron Company, Limited.—Profit, £143,763; brought in, £113,375; provision for income-tax, £28,500; written off for redemption and depreciation, £45,000; final dividend on the ordinary shares of 2½ per cent., making 5 per cent.; carried forward, £118,513.

International Nickel Company of Canada, Limited.—Trading profits, $14,550,437; depreciation, $1,217,833; retirement system and insurance reserve, $376,521; net profit, $12,393,317; preferred dividends, $557,034; common dividends, $4,331,095; surplus at December 31, 1928, $33,169,819.

New Companies.

W. E. Hacking, Limited, 88, Oxford Road, Burnley.—Capital £800. Ironfounders, etc.

Arthur Andrews, Limited.—Capital £10,000. Engineers, etc. Solicitors: R. A. Rotherham & Company, Coventry.

Samuel Jones & Company (Engineering), Limited, 7, Bridewell Place, London, E.C.—Capital £20,375. Directors: A. C. Jennings and L. M. Jones.

S. Steen & Company, Limited, 18, Cullum Street, London, E.C.—Capital £100. Metal merchants. Directors: S. P. Steen, A. Ash and W. H. Gray.

Brunler Furnace (Foreign) Company, Limited, 35, Walbrook, London, E.C.—Capital £15,000 in £1 shares. Directors: O. Brunler and J. K. K. Paterson.

Erryrys Silica and Spar Company, Limited, Castle Buildings, 66, Bridge Street, Chester.—Capital £10,000. Directors: H. G. Chesters and S. R. Griffiths.

N. M. Clougher & Company, Limited.—Capital £5,000. Engineers, etc. Directors: N. M. Clougher, 28, Craven Street, London, W.C.; and T. R. Clougher.

Personal.

Sir James Lithgow, Bt., has been elected President of the Institution of Engineers and Shipbuilders in Scotland for the ensuing year.

Mr. J. Ferdinand Kayser, Assoc. Met., has been appointed as metallurgist and technical adviser for Europe to the Crucible Steel Company of America, whose London offices are at 31-32, Borough Road, S.E.1.

Mr. Robert Crichton, vice-chairman of the Scottish Iron and Steel Company, Limited, has been appointed a director of the United Steel Companies, Limited, and is leaving shortly to take up duties at Workington. Mr. Crichton is well known in Scottish iron and steel circles, and is president of the West of Scotland Iron and Steel Institute this year.

Wills.

Robert Morgan, brassfounder, Dumbreck, Glasgow £12,551

James Richardson, B.Sc., engineering manager, William Beardmore & Company, Limited, Dalmuir £3,362

Mr. Alexander Spence Millar, shipbuilder, Grangemouth, director of the Grangemouth Dockyard Company, Limited £189,674

Obituary.

Mr. George S. Siddle, manager of the Linthorpe-Dinsdale Smelting Company, Limited, died recently.

The death is announced of Mr. David Yuille, of the Winton Foundry Company, Limited, Ardrossan, on April 4.

The death is announced, at Moseley, Birmingham, of Mr. M. H. Mitchell, who for over 20 years was manager of Mr. Ernest Wilkes's foundry at Pelsall, near Wolverhampton.

The death has occurred of Mr. Thomas Hutchinson, who until his retirement some two years ago was secretary of the Whessoe Foundry and Engineering Company, Limited, Darlington.

Mr. G. Stocks, ironworker, has died in the Royal Infirmary, Glasgow, as the result of being struck by a crane load of angles and crushed against a pillar, whilst working in the Lochrin Ironworks, Coatbridge.

Mr. Frederick Holman, of Messrs. N. Holman & Sons, Limited, engineers and ironfounders, Penzance, died on March 24 at the age of 87 years. Mr. Holman was one of the oldest members of the Institution of Mechanical Engineers.

Mr. Dudley S. Majoribanks, who had been associated with Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, at Elswick, for half a century as labour adviser, died at Corbridge on March 29 in his 72nd year. He was made a C.B.E. for services rendered in connection with labour questions during the war.

Mr. James F. Mason, chairman of Messrs. Mason & Barry, Limited, London, who have copper-mining interests in Portugal, died last week, in London, at the age of 67. Mr. Mason, who was also a director of Messrs. Dorman, Long & Company, Limited, and of the Great Western Railway Company, represented Windsor in the House of Commons for 12 years, from 1906 until the close of the war.

The death is announced of Mr. James Wilson, cashier to the Dorrator Iron Company, Falkirk. Mr. Wilson was well known in Falkirk foundry circles, and, although he had not been in the best of health since the New Year, was able to continue at business until about ten days prior to his death. A native of Falkirk, he was originally employed by the Carron Company and later by the Grangemouth Iron Company. He was appointed cashier to the Dorrator Iron Company over 20 years ago.

Bethlehem Steel Corporation.—The Bethlehem Steel Corporation's net income for 1928, after providing $13,658,335 for depreciation and depletion, amounted to $18,585,922, as compared with $15,826,142 for 1927. Surplus after paying preferred dividends of $6,842,500 amounted to $11,743,422, equivalent to $6.52 per share on the common stock as compared with $5.02 in 1927. A common stock dividend of 1 per cent. amounting to $1,800,000 was declared January 24, 1929. Gross sales for the year amounted to $294,778,287, as compared with $271,502,891 for 1927.

TRADE MARK.

"SERVICE BCM/GX FIRST"

SHEFFIELD STANDARD GANISTER

If a Cupola man shall pause from his lining,
And, full of despair, raise his voice in repining,
You will say to him, "Bill!
Now what is your will?
Say, what is your woe and why are you whining?"

If William's the man that I have in my mind
He will say to you, "Boss, tha' wert never unkind,
But tha's buying us stuff
Not sticky enough,
Not plastic and tough, never likely to bind.

"This rubbish is Ganister—only i'name
It's not the 'Best Sheffield,' so well known to fame.
It's price cutting muck
That gets us no luck
But brings half the troubles for which we get blame.

"The lowest price stuff's never cheapest i't'end
Watch the quality, too, when tha's money to spend.
Our coke is the best
And we buy it on test,
But for lining t'owd Cupola—why it's owt that they send!"

"Why, Bill," you will answer, "I'm sorry, my lad,
I know it's hard work when the Ganister is bad.
You shall have your own way
Now what do you say?
What's the very best Ganister you've ever had?"

"Why, Sheffield Standard Ganister is t'only kind to buy"
Bill said and wiped a tear of joy from out his bright blue eye.
"I used it in my youth
And I tell thi' Sir, the truth
Tha'll never want to change again nor think as t'price is high."

QUALITY IN GANISTER

Much harm has been done to the Ganister Industry by the indiscriminate sale of low grade mixtures as "Best Ganister."

The results of their use have given vendors of high priced Ganister substitutes an opportunity that would never have occurred if all makers of Ground Ganister had maintained a fair price for a high quality material likely to give the best possible service to the user.

Such a grade is now being made in large quantities and of guaranteed high quality, hand selected, raw materials under the description—

"STANDARD SHEFFIELD GANISTER"

by the

GENERAL REFRACTORIES Co., Ltd.

SHEFFIELD.

London. **Glasgow.**

'Phone :—
Sheffield 22311.

Telegrams :—
"*Genefrax, Sheffield.*"

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—For the present the outlook in the Cleveland iron trade maintains the confident tone expressed in recent reports, tending to the expectation of continuous and progressive expansion of demand, both for home consumption and export purposes. With regard to the last-named section, it is interesting and instructive to note the significant fact that Tees pig-iron shipments last month were the heaviest for any month since April, 1926. Coastwise shipments to Scotland have also improved, but the heaviest increase has been in the foreign trade, and now that the Baltic season is at hand, a further expansion in the volume of overseas trade is anticipated. The position thus created has necessarily accelerated the movement on the part of the Tees-side ironmasters to increase production, and present expectations are that the recent starting of a blast furnace on Cleveland foundry iron at the Clarence Works will be followed by the rekindling of another blast furnace at the Newport Ironworks shortly. The need is urgent, but adequate supplies of coke are difficult to procure. Meanwhile consumers are continuing to buy for May-June delivery, and even further forward. Quotations have been increased, and are now as follows :—No. 1 foundry iron, 71s. per ton; No. 3 G.M.B., 68s. 6d.; No. 4 foundry, 67s. 6d.; No. 4 forge, 67s. per ton.

Pressure of demand continues the predominant note in the market for East Coast hematite, both home and export inquiries disclosing equal activity, with increasing difficulty on the part of makers to meet prompt deliveries on an adequate scale. The current quotation remains, however, unchanged, though firm, at 74s., with the usual extra 6d. per ton for No. 1 quality. On the North-West Coast also Bessemer mixed numbers are still quoted at 74s per ton at works.

LANCASHIRE.—As testifying to the steady and continuous improvement in the local markets for foundry pig, it may be noted with satisfaction that during the just completed quarter of the current year sales and deliveries to consumers have been on an appreciably better scale than for some time past. Prices are also substantially firmer, current quotations for local deliveries ruling:—Derbyshire No. 3, 71s.; Staffordshire, 71s.; with Scottish brands at about 90s., all per ton.

THE MIDLANDS.—Business in this area, on the whole, continues quiet, orders for foundry work showing little improvement since last reported. Prices are unchanged, Derbyshire No. 3 being at 72s. 6d., Staffordshire No. 3 75s., and Northants No. 3 at 69s., delivered Birmingham and Black Country stations.

SCOTLAND.—Conditions in the Scottish markets for foundry pig continue unsatisfactory, most of the Falkirk works being short of orders. There is no change to report in the basis price, which remains at 72s. 6d. per ton for No. 3 Scotch foundry, f.o.t. furnaces. The price is firmly held, and looks as if it might be advanced any day.

Finished Iron.

For the first time for a very long period it is satisfactory to report some improvement in the demand for bar iron, in crown and the better grades especially. Recent prices are upheld, and it would not be surprising to find further advances taking place in view of the difficulty of getting scrap and also its higher cost. A good crown iron now costs between £9 15s. and £10, although certain brands can be obtained at between £9 7s. 6d. and £9 12s. 6d. An average price for nut and bolt iron would be £9 per ton delivered in this area, but the mills are not receiving much business for this class of iron, as the bulk of the orders is going to the Continent. The foreign product is quoted at £7 2s. 6d. to £7 5s., delivered this area. There has been no change in the price of Staffordshire marked bars, the figure being £12 at makers' works.

Steel.

Reports from Sheffield manufacturers of finished steel continue favourable to a further expansion of trade in this direction, while the bulk of the business being placed by British buyers of semi-products is still going to the home works, owing to the continued difficulty in obtaining delivery of Continental material. Continental semis are still competitive in price, but little prompt material is available for the British market, and any orders going abroad are for delivery a good way ahead. Many of the British works have a considerable tonnage of orders on their books, and as a result of this, and owing, also, to the higher costs of raw material, prices are firm. Production of sheet and tinplate bars at the South Wales steelworks is on an active scale. Prices of tinplates, owing to the increased cost of bars, are maintained at the higher levels recorded last week, but the market remains quiet, and the amount of new business booked is small.

Scrap.

A rather quieter demand for foundry scrap material is now in evidence in most markets, and on the North-East Coast this week quotations for ordinary heavy cast iron being unchanged at round about 62s. 6d., and machinery quality at 66s., but it is difficult to find a seller. In the Midlands, heavy cast iron in large pieces and furnace sizes is more active and firmer at 65s. to 67s. 6d. Good cast-iron machinery scrap for foundry purposes is not in great demand, but is firmer at 67s. 6d. to 70s. In the Scottish markets, cast-iron scrap, if anything, is a little quieter, and it is difficult now to dispose of machinery quality at 73s. 6d. For heavy ordinary cast-iron scrap to the same specification, 67s. 6d. to 68s. 6d. is quoted. Old cast-iron railway chairs are around 70s., with light cast-iron at around 67s. 6d. and old cast-iron firebars at 64s., all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Following the recent rather sensational upward movements in warrant copper, which at one time nearly touched the £100 level, it is not surprising that a sharp reaction in values has developed, quotations having receded in mid-week to below £80. This weakening of values has been largely caused by the heavy buying producing an unfavourable technical position, and any advances which occurred were impeded by selling and liquidation.

Closing quotations are :—

Cash.—Thursday, £89 7s. 6d. to £89 10s.; Friday, £86 10s. to £86 15s.; Monday, £88 to £88 5s.; Tuesday, £79 5s. to £79 7s. 6d.; Wednesday, £77 15s. to £78.

Three Months.—Thursday, £89 12s. 6d. to £89 15s.; Friday, £85 17s. 6d. to £86; Monday, £87 7s. 6d. to £87 10s.; Tuesday, £77 15s. to £78; Wednesday, £75 15s. to £76.

Tin.—The position in the market for standard cash tin has now assumed a steadier tendency, and in the absence of an excessive speculative element business has returned to more normal conditions. Reports from the Continent indicate quieter conditions there, and as a result of the recent irregularities of this metal the demand from consumers has slackened off to some extent. With regard to the future, the balance of supply and demand at the moment seems so good that any development might rapidly change the whole situation.

Official closing prices :—

Cash.—Thursday, £218 10s. to £218 12s. 6d.; Friday, £217 10s. to £217 15s.; Monday, £216 2s. 6d. to £216 5s.; Tuesday, £208 15s. to £208 17s. 6d.; Wednesday, £208 7s. 6d. to £208 10s.

Three Months.—Thursday, £218 17s. 6d. to £219; Friday, £217 5s. to £217 7s. 6d.; Monday, £216 10s. to £216 15s.; Tuesday, £209 to £209 5s.; Wednesday, £209 to £209 5s.

Spelter.—The outlook for zinc is firm and statistics indicate that the consumption is everywhere increasing. The fact that stocks are nowhere large points to the fact that the consumpton has increased with the demand, and at the moment it seems likely that for some time to come the consumption will be in excess of the production.

Daily quotations are :—

Ordinary. — Thursday, £27 5s.; Friday, £26 18s. 9d.; Monday, £26 17s. 6d.; Tuesday, £26 15s.; Wednesday, £26 12s. 6d.

Lead.—Markets for this metal have not yet fully recovered from the recent burst of extraordinary activity, and consumers, on the whole, have been quiet during the past week. The recent rush was merely a case of large buying in excess of the supplies that were immediately available, so that the relapse in values which is now experienced is only the natural outcome of that unnatural state of affairs.

Soft Foreign Prompt.—Thursday, £26 6s. 3d.; Friday, £24 10s.; Monday, £25; Tuesday, £24 15s.; Wednesday, £23 17s. 6d.

Students' Corner

Q.—How would you describe oil sand cores?

A.—Cores made with silica sands such as dune, beech, and sea sands, devoid of bonding matter; also white silica sands, that are of very fine grains, clean, and of high purity, mixed with an artificial binder.

Q.—Which of the many types of artificial binders do you consider preferable?

A.—It is difficult to choose which is best and most economical, whilst not holding a brief for any of them, personal preference is for an artificial binder with a linseed oil base.

Q.—What are the desirable properties of a good core oil?

A.—Core oils have the property of becoming sticky and hard when exposed to the air. They are known as "drying oils," and linseed oil is the best known and most commonly used.

For bonding purposes in the foundry it is usually boiled together with gums, resins, etc., to improve its bonding properties. Boiled raw linseed oil alone would produce in a dried core a film-binder that would be almost impermeable, hence undesirable.

A good core oil should, when dried, be moisture-proof—free from excess stickiness to the core boxes—should mix easily with the sand—its fumes should not be objectionable either when drying, or at casting time—possess good bonding properties—and run freely from the castings when being cleaned—ability to withstand erosion and support various stresses to which it is subjected during pouring.

Q.—What are cores made from other than oil sand?

A.—They are made from foundry sands containing a natural bond such as a clay substance.

Q.—Do oil-sand cores possess the same strength as cores made from natural-bonded sands?

A.—Oil-sand cores when dried are stronger than cores made from a natural-bonded core sand. Tests to destruction have shown that an oil-sand core, 6 in. long by 1 in. sq., loaded in the centre, and resting on 4-in. supports, may withstand 112¼ lbs. before breaking and give a compression test on a 2½-in. cube of 3 tons.

Q.—What is the usual proportion of oil to sand?

A.—About 1 of oil to 40 of sand, or 3 to 4 per cent. of oil, *i.e.*, a core-oil with a linseed base. With other binders the percentage may vary enormously.

Q.—What is a good method of mixing the oil and sand?

A.—For accurate working, the sand to be treated should be dried. The oil and water should be previously mixed into an emulsified form, and applied while it is in that form. If allowed to stand for any length of time it will separate out, *id est*, the oil, from the water. It is best mixed in some form of a paddle mixer, of which there are several mechanical types.

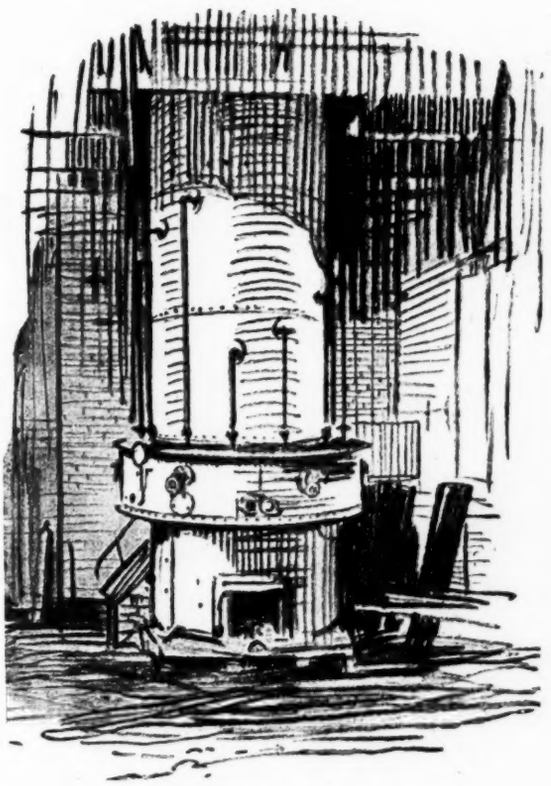
MELTING EFFICIENCY IS OBTAINABLE

WITH THE

POUMAY SYSTEM OF CUPOLA CONTROL

SUCH AS IS ONLY POSSIBLE WITH THE ADOPTION OF THIS STARTLING NEW PRINCIPLE

HERE IS AN ILLUSTRATION OF A TRANSFORMED CUPOLA



THE ALTERATIONS NECESSARY ARE VERY SMALL AND SIMPLE TO EXECUTE

YOUR PRACTICE IS RENDERED HIGHLY EFFICIENT —— LARGE SAVINGS BEING THE OBVIOUS OUTCOME

CAN YOUR PRACTICE BE IMPROVED?

SATISFY YOURSELF AND SEE

WITHOUT OBLIGATION WHAT CAN BE SAVED IN YOUR CASE.

BRITISH DRYING & HEATING CO., LTD.

15, King Street, London, S.W.1

Telephone: Gerrard 4514. *Telegrams: Britdriet, Piccy, London.*

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	77	15	0
Three months	75	15	0
Electrolytic	85	0	0
Tough	84	10	0
Best selected	85	0	0
Sheets	133	0	0
India	114	0	0
Wire bars	100	0	0
Do. April	100	0	0
Do. May	100	0	0
Ingot bars	Nominal		
H.C. wire rods	Nominal		
Off. av. cash, March	89	4	4½
Do. 3 mths., March	90	11	0
Do., Sttlmnt., March	89	3	6
Do., Electro, March	98	16	10½
Do., B.S., March	95	9	2
Aver. spot price, copper, Mar.	89	4	4½
Do. wire bars, March	99	6	7½
Solid drawn tubes			18½d.
Brazed tubes			18½d.
Wire			14½d.

BRASS.

Solid drawn tubes	15½d.
Brazed tubes	17½d.
Rods, drawn	13⅞d.
Rods, extd. or rlld.	9d.
Sheets to 10 w.g.	13½d.
Wire	12⅞d.
Rolled metal	12⅞d.
Yellow metal rods	9d.
Do. 4 × 4 Squares	10d.
Do. 4 × 3 Sheets	10½d.

TIN.

	£	s.	d.
Standard cash	208	7	6
Three months	209	0	0
English	208	15	0
Bars	210	15	0
Straits	210	5	0
Australian	209	15	0
Eastern	217	0	0
Banca	213	5	0
Off. av. cash, March	220	17	4½
Do., 3 mths., March	221	15	5¼
Do., Sttlmt., March	220	17	6
Aver. spot, March	220	17	4½

SPELTER.

	£	s.	d.
Ordinary	26	12	6
Remelted	26	5	0
Hard	21	15	0
Electro 99.9	30	0	0
English	27	7	6
India	23	0	0
Zinc dust (Nom.)	36	17	6
Zinc ashes	8	15	0
Off. aver., March	27	3	5¼
Aver., spot, March	27	1	0

LEAD.

	£	s.	d.
Soft foreign ppt.	23	17	6
English	25	10	0
Off. average, March	25	9	11¼
Average spot, March	25	8	2¼

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	34	15	0
Do. V.M. ex whf.	33	5	0
Rods	43	0	0
Boiler plates	32	0	0
Battery plates	33	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	54	10	0
Chinese	38	0	0
Crude	33	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	22	3	9

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	17	6
45/50%	12	0	0
75%	19	10	0
Ferro-vanadium—			
35/50%	£13/9 lb. Va.		
Ferro-molybdenum—			
70/75% c. free	£3/8 lb. Mo.		
Ferro-titanium—			
23/25% carbonless	11d. lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%, c. fr.	2/1½ lb.		
Tungsten metal powder—			
98/99%	2/3½ lb.		
Ferro-chrome—			
2/4% car.	£35	0	0
4/6% car.	£25	0	0
6/8% car.	£24	0	0
8/10% car.	£23	10	0
Ferro-chrome—			
Max. 2% car.	£35	0	0
Max. 1% car.	£38	0	0
Max. 0·70% car.	£42	0	0
70%, carbonless	1/2 lb.		
Nickel—99%, cubes or pellets	£175	0	0
Ferro-cobalt	9/4 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	2/6 lb.		
Ferro-manganese (net)—			
76/80% loose	£13	15	0
76/80% packed	£14	15	0
76/80%, export	£14	10	0
Metallic manganese—			
94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finshed bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in.	1/- lb.
Flats, ¼ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel				4	0	0
Bundled steel and shrngs	3	10	0 to	3	17	6
Mixed iron and steel	3	10	0 to	3	12	6
Heavy cast iron	3	5	0 to	3	7	6
Good machinery for foundries	3	7	6 to	3	10	0
Cleveland—						
Heavy steel				3	3	6
Steel turnings				2	15	6
Cast iron borings				2	10	0
Heavy forge				3	15	0
W.I. piling scrap				3	10	0
Cast-iron scrap	3	2	6 to	3	6	0
Lancashire—						
Cast-iron scrap	2	15	0 to	3	10	0
Hvy. wrought				3	12	6
Steel turnings				2	12	6
Scotland—						
Heavy steel				3	15	0
Cast-iron borings				2	17	6
Wrought-iron piling				3	12	6
Heavy machinery				3	14	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	70	0	0
Brass	45	0	0
Lead (less usual draft)	22	0	0
Tea lead	20	0	0
Zinc	19	0	0
New aluminium cuttings	67	0	0
Braziery copper	64	0	0
Gunmetal	60	0	0
Hollow pewter	160	0	0
Shaped black pewter	105	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	71/-
Foundry No. 3	68/6
Foundry No. 4	67/6
Forge No. 4	67/-
Hematite No. 1	74/6
Hematite M/Nos.	74/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	81/6
„ d/d Birm.	90/6
Midlands—	
Staffs. common*	—
„ No. 4 forge*	71/-
„ No. 3 fdry*	75/-
Shrops. basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	65/-
„ fdry. No. 3*	69/-
Derbyshire forge*	68/6
„ fdry. No. 3*	72/6
„ basic*	—

* d/d Black Country dist.

Scotland—	
Foundry No. 1	75/-
„ No. 3	72/6
Hem. M/Nos.	77/-
Sheffield (d/d district)—	
Derby forge	63/6
„ fdry. No. 3	67/6
Lincs. forge	67/6
„ fdry. No. 3	71/6
E.C. hematite	84/-
W.C. hematite	86/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 3	71/-
Northants foundry No. 3	—
Dalzell, No. 3 (special)	100/- to 102/6
Summerlee, No. 3	90/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	90/-
Monkland, No. 3	90/-
Shotts, No. 3	90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.				10	5	0
Nut and bolt iron	8	17	6 to	9	0	0
Hoops				11	10	0
Marked bars (Staffs.) f.o.t.				12	0	0
Gas strip				11	10	0
Bolts and nuts, ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates	8	7	6 to	8	12	6
Boiler plts.				10	10	0
Chequer plts.				10	12	6
Angles				7	17	6
Tees				8	17	6
Joists				7	17	6
Rounds and squares, 3 in. to 5½ in.				8	17	6
Rounds under 3 in. to ¾ in. (Untested)				7	15	0 and upwards
Flats, over 5 in. wide and up				8	7	6
Flats, 5 in. to 1½ in.				7	17	6
Rails, heavy				8	10	0
Fishplates				12	10	0
Hoops (Staffs.)				11	0	0
Black sheets, 24g.	10	0	0 to	10	10	0
Galv. cor. shts., 24g.	13	7	6 to	13	15	0
Galv. fencing wire 8g. plain				11	10	0
Billets, soft	6	5	0 to	7	0	0
Billets hard	7	5	0 to	8	0	0
Sheet bars	6	2	6 to	6	6	6
Tin bars	6	2	6 to	6	6	6

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/6
Sheet to 10 w.g.	1/7
Wire	1/8½
Rods	1/7
Tubes	2/-
Castings	1/6

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	1/- to 1/6
Rolled—	
To 9 in. wide	1/6 to 2/-
To 12 in. wide	1/6½ to 2/0½
To 15 in. wide	1/6½ to 2/0½
To 18 in. wide	1/7 to 2/1
To 21 in. wide	1/7½ to 2/1½
To 25 in. wide	1/8 to 2/2
Ingots for spoons and forks	1/- to 1/8½
Ingots rolled to spoon size	1/3 to 1/11½
Wire round—	
3/0 to 10 G.	1/9½ to 2/4½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	15.50
Basic	19.26
Bessemer	20.79
Malleable	20.01
Grey forge	19.26
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	34.00
O.-h. billets	34.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	25/- to 30/-
„ furnace	21/- to 23/-
Durham and North.	
„ foundry	19/- to 20/-
„ furnace	17/- to 17/6
Midlands, foundry	—
„ furnace	17/- to 17/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/3
„	28×20 „	36/6
„	20×10 „	26/3
„	18¾×14 „	18/9
C.W.	20×14 „	15/-
„	28×20 „	33/6
„	20×10 „	21/3
„	18¾×14 „	15/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	10	0
Bars, hammered, basis	£17	10	0 to	£18	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	15	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£32	0	0 to	£33	0	0
Faggot steel	£20	0	0 to	£24	0	0
Bars and rods, dead soft, steel	£10	0	0 to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	50%
Water	63¾%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
April	4	89	7	6	dec.	130/-
,,	5	86	10	0	,,	57/6
,,	8	88	0	0	inc.	30/-
,,	9	79	5	0	dec.	175/-
,,	10	77	15	0	,,	30/-

Electrolytic Copper.

		£	s.	d.		
April	4	104	0	0	dec.	80/-
,,	5	104	0	0	No change	
,,	8	104	0	0	,,	,,
,,	9	90	0	0	dec.	280/-
,,	10	85	0	0	,,	100/-

Standard Tin (cash).

		£	s.	d.		
April	4	218	10	0	dec.	20/-
,,	5	217	10	0	,,	20/-
,,	8	216	2	6	,,	27/6
,,	9	208	15	0	,,	147/6
,,	10	208	7	6	,,	7/6

Tin (English ingots).

		£	s.	d.		
April	4	218	10	0	dec.	20/-
,,	5	217	10	0	,,	20/-
,,	8	216	5	0	,,	25/-
,,	9	208	15	0	,,	150/-
,,	10	208	15	0	No change	

Zinc Sheets (English).

		£	s.	d.		
April	4	35	10	0	No change	
,,	5	35	10	0	,,	,,
,,	8	35	10	0	,,	,,
,,	9	34	15	0	dec.	15/-
,,	10	34	15	0	No change	

Spelter (ordinary).

		£	s.	d.		
April	4	27	5	0	dec.	8/9
,,	5	26	18	9	,,	6/3
,,	8	26	17	6	,,	1/3
,,	9	26	15	0	,,	2/6
,,	10	26	12	6	,,	2/6

Lead (English).

		£	s.	d.		
April	4	27	10	0	dec.	10/-
,,	5	26	5	0	,,	25/-
,,	8	26	5	0	No change	
,,	9	26	0	0	dec.	5/-
,,	10	25	10	0	,,	10/-

AVERAGE MONTHLY PRICES OF STEEL SHIP PLATES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 2 6	5 10 0	5 10 0	5 2 6
1897	5 10 0	5 10 0	5 10 0	5 7 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 7 6	5 10 0	5 10 0	5 5 5
1898	5 10 0	5 8 9	5 8 9	5 10 0	5 16 3	5 18 9	5 17 6	6 0 0	6 2 6	6 5 0	6 10 0	6 15 0	5 18 6½
1899	6 15 0	7 0 0	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 12 6	7 12 6	7 12 6	7 12 6	8 0 0	7 6 5½
1900	8 0 0	8 0 0	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 0 0	8 0 0	8 0 0	7 10 0	7 0 0	8 0 0
1901	6 15 0	6 15 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 7 6	6 5 0	6 0 0	6 0 0	6 4 4
1902	5 17 6	5 12 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 14 7½
1903	5 10 0	5 10 0	5 15 0	6 0 0	6 0 0	6 0 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 10 0	5 13 11
1904	5 7 6	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 11 10
1905	5 15 0	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	6 0 0	6 10 0	7 0 0	7 0 0	7 0 0	6 2 3½
1906	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 10 0	7 0 10½
1907	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 8 4
1908	6 10 0	6 10 0	6 10 0	6 5 0	6 5 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 3 9
1909	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	5 15 0	5 15 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	5 18 9
1910	6 5 0	6 5 0	6 7 6	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 2
1911	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 18 4	6 15 3½
1912	7 3 9	7 5 0	7 5 0	7 12 6	7 15 0	7 15 0	7 15 0	8 0 0	8 0 0	8 0 0	8 2 0	8 5 0	7 14 10
1913	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	7 19 0	7 15 0	7 3 0	6 15 0	6 10 0	7 16 5½
1914	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 0 0	6 0 0	7 0 0	7 5 0	7 5 0	7 6 3	7 10 0	6 14 8½
1915	8 0 0	8 10 0	9 0 0	9 10 0	9 10 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 5 0	11 0 0	9 12 11
1916	11 7 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 9 2
1917	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 6
1918	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0
1919	11 10 0	14 0 0	14 0 0	14 0 0	17 0 0	17 7 6	17 15 0	18 5 0	18 5 0	18 5 0	19 12 6	21 5 0	16 15 5
1920	22 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	24 0 0	24 10 0	24 5 0	24 5 0	23 13 4
1921	23 5 0	22 10 0	20 4 0	19 0 0	19 0 0	17 9 0	15 0 0	14 15 0	13 12 0	12 5 0	10 10 0	10 10 0	16 9 3
1922	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 0	10 0 0	9 7 6	9 4 0	9 5 0	9 5 0	9 5 0	9 18 4½
1923	9 7 6	9 15 0	10 5 0	10 10 0	10 10 0	10 10 0	9 18 9	9 17 6	9 17 6	9 18 6	10 6 10½	10 1 2½
1924	10 1 6	9 18 1½	9 17 6	9 17 6	9 17 6	9 19 4½	10 5 0	10 5 0	10 5 0	9 19 0	9 15 0	9 15 0	9 19 7½
1925	9 14 0	9 10 0	9 10 0	9 1 3	9 0 0	9 0 0	8 17 0	8 13 1½	8 7 6	8 5 6	7 16 3	7 14 3	8 15 8½
1926	7 12 2½	7 12 6	7 12 6	7 14 4½	7 15 0	7 16 10½	8 2 6	8 2 6	8 4 0	8 12 6	8 12 6	8 16 3	8 1 1½
1927	8 17 6	8 17 6	8 11 6	8 7 6	8 6 3	8 5 0	8 5 0	8 3 9	8 2 6	8 2 6	8 5 0	8 5 0	8 7 5·1
1928	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 6 10½
1929	8 7 6	8 7 6	8 7 6	—	—	—	—	—	—	—	—	—	—

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